the Petroleum Engineer

FOR MANAGEMENT

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

A Report On

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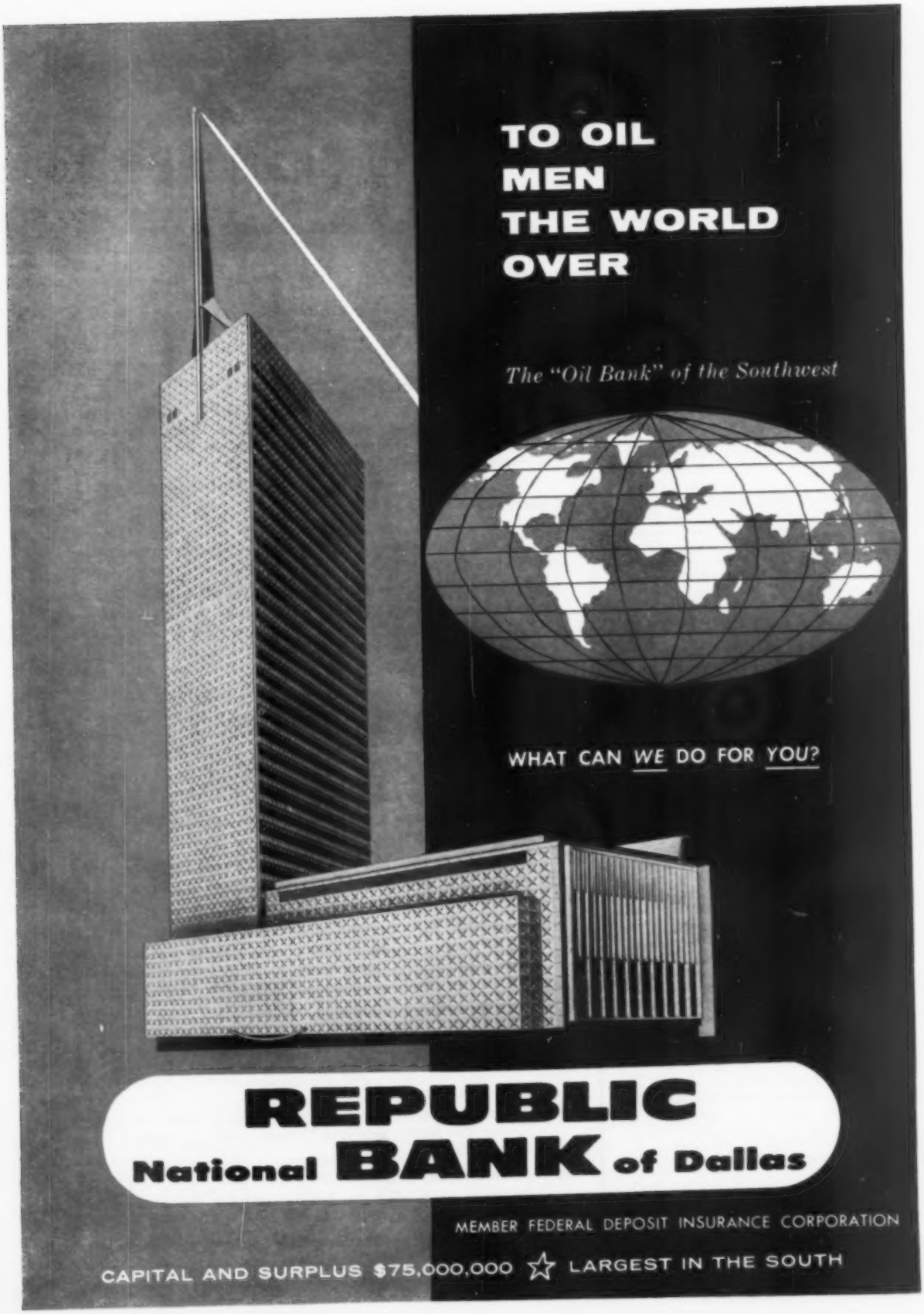
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Country of Bright Promise

VENEZUELA stands out as a leader in South America. It has rich resources and it is developing them on a sound economic basis. The government uses returns from natural resources to obtain worthy social and cultural objectives.

Politically Venezuela has had a long struggle toward stabilization. A republican form of government on paper, its conservatives and liberals have more often fought with guns than with votes. But progress has been made in this direction, too. The government today spends more than half its income on public works and economic development. Much goes to education and health centers, to slum clearance and highways — the things that prepare a vigorous people to assume their responsibilities, to realize their capabilities.

More than any other, the petroleum industry has contributed to the economic well being of the country. It has built modern towns, schools, hospitals, roads. It has provided wages, training, education for thousands of Venezuelans.

The industry could do these things and prosper because it was able to operate much as it does in the United States. Venezuela is one of the bright countries of the world that believes in keeping government and business separate. For want of a better term we call it free enterprise. Although it is well regulated and well taxed, business is run by its own management.

One highly important aspect of petroleum operations in Venezuela is that the government bureau in charge of these activities is experienced and knowledgeable. Minister of Mines and Hydrocarbons, Dr. Edmundo Luongo Castillo, and Director of Hydrocarbons, Dr. Gustavo Thery Fombona, know both the government and operating phases of petroleum. Their staffs are well educated and well trained. They keep the interests of the nation and of the oil companies so skillfully balanced that each receives satisfactory returns — one for its resources and the others for their investments and operations.

This is not an easy feat and other countries would do well to observe not only the petroleum laws of Venezuela that work so successfully, but the fact — so often overlooked — that administering them requires men of dedicated purpose.

We have chosen Venezuela as the No. 1 Foreign Area of Promise because it has the largest production of oil outside the United States; because its laws are well drawn and judiciously administered; because it is open to all private companies of any nationality but is closed to companies owned in whole or in part by other governments; because its government is using its gains for widespread economic and social progress.

And because we feel that, although today's achievements are dramatic, the potential for industry and for Venezuela is incalculably greater.

Ernestine Adams

Congrats and $25 to Samuel J. Martinez, 1830 East 15th St., Tulsa 4, Oklahoma, for this quip.

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Petroleum Profile

From his 10th floor office in Creole Petroleum Corporation's new building in Caracas, Harold W. Haight, Creole's energetic president, can look out over a spectacular panorama of natural beauty embellished by construction which has made the Venezuelan capital one of the world's fastest growing cities.

Caracas lies in a valley surrounded by mountains of striking beauty. Complementing this impressive natural setting is the amazing growth of the city itself. The valley is criss-crossed by modern super-highways; gleaming structures of glass, steel and concrete are springing up on all sides; and directly below Haight's window, across the street from the Creole building, is to be seen the architectural complex of University City. Some of the most advanced design and decoration of modern architecture is found in this big educational plant, which is a symbol of Venezuela's progress and development.

As president of the largest company in an industry which provides a substantial portion of the revenue which makes this growth and improvement possible, Haight could, if he chose, derive a great deal of satisfaction from that ever-changing view. But it is likely that he doesn't give much time to such reflections. He is too busy running the affairs of Creole (top affiliate of Jersey Standard) which last year had a gross income of just a whisker under one billion dollars and which reported profits of $336 million.

Haight, widely-known as "Duke," has had long experience in the oil business and all of it has been abroad. This has equipped him admirably for his present post because the relationships between the Venezuelan government and the oil companies that have helped to develop the nation's natural resources are necessarily close.

Haight began his career 30 years ago in Mexico, with a Jersey affiliate, Compania Transcontinental de Petroleo, and he has been with Jersey ever since. It was in Mexico that he acquired his nickname. From Mexico he went to Egypt in 1937, as manager of Jersey's affiliate there, Standard Oil Company of Egypt; in 1939 he was named managing director. Eight years later, Haight was sent to Venezuela to take over as production manager. He had been tapped as executive material away back in his Mexican days, when he was not only getting along famously with the people and the officials there, but was also putting in some hard licks at learning all there was to learn about the oil business.

HAROLD W. HAIGHT
President
Creole Petroleum Corporation

In 1946 he was elected a vice president of Creole and member of the board of directors and he moved up to the executive vice presidency in 1950. When Arthur T. Proudfit, another veteran in the Jersey family who also started out in Mexico, was named to the board of directors of the parent company in November 1954, Haight moved into his place as president of Creole.

In this position, Haight bears full responsibility for the company's relations with the Venezuelan government, in addition to the many other responsibilities that fall to him. He is Creole's representative before the Venezuelan nation and its people, and because of the company's importance in Venezuela's economic structure, this makes him a figure of the first rank.

Haight flourishes under these circumstances. He is gregarious by nature, and this penchant for being with people, coupled with his accomplished handling of the Spanish tongue, has made him a favorite with the Venezuelans. He is an enthusiastic member of the Rotary Club of Caracas, and frequently makes public addresses.

One of the basic principles of Creole's policy is to make every effort to show that the company is a Venezuelan institution, a good citizen of the community where it operates, and Haight takes the lead in his deeds and his actions in exemplifying this policy. He insists that all Americans who work for Creole must speak and understand Spanish, and he encourages them to "integrate" with the Venezuelan community.

Duke Haight is a hard worker himself and he demands the maximum effort from his subordinates. He is bluff and hearty, but he can also become the stern taskmaster if he feels an employee is not giving everything he has to his job.

Mr. and Mrs. Haight—the former Jean Scoles Kirkpatrick of Joplin, Missouri—have one married daughter, who lives on the island of Aruba, just off Venezuela's coastline, where her husband is employed by Lago Oil & Transport Company, another Jersey affiliate, at its large refinery. There is one grandson, who is six years old.

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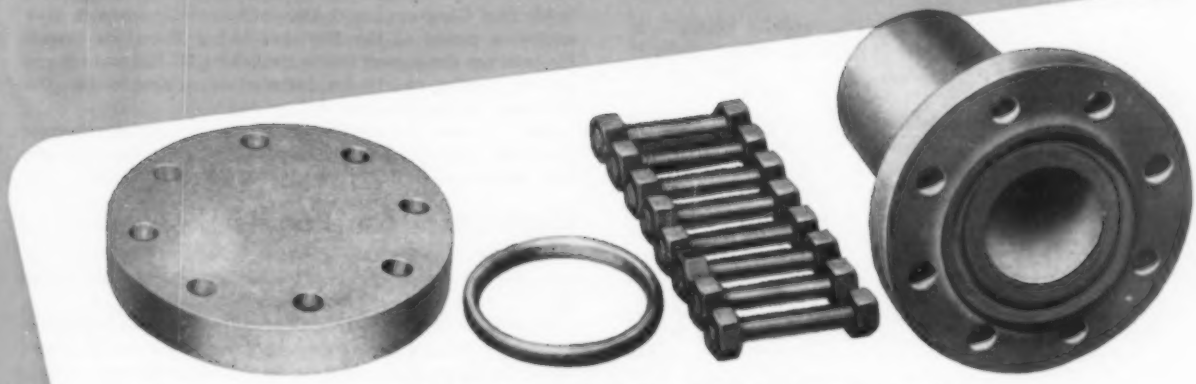

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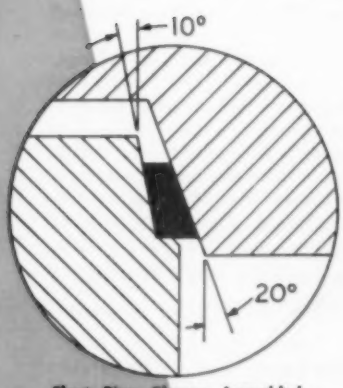

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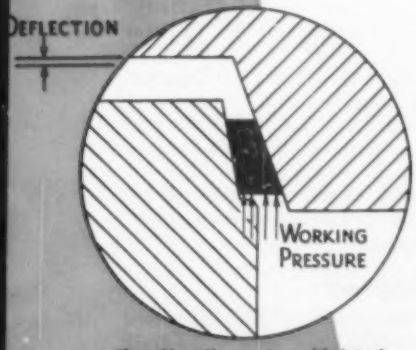

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THE CONFERENCE TABLE

The essence of genius is to know what to overlook. — WILLIAM JAMES

Fabled Land

Biggest producer of oil — next to United States — is Venezuela, our sister Republic to the South. This issue will supply a volume of information about the country and its oil and gas operations.

Venezuela has set an example that many countries are following. Its reliance on private capital enterprise has been rewarded by better economic conditions than any country of its size and population. Tremendous strides have been made in public works and in health and economic growth. The federal government has a balanced budget and a substantial reserve.

Recent offer of new oil concessions brought a score or more new companies into Venezuela. The government, whose Ministry of Mines and Hydrocarbons is efficiently run by experienced engineers, has wisely held the door open to small operators, who say they are getting a square deal.

General concensus of companies that have been in Venezuela a long time is to welcome new concessionaires. They are ready to share production in order to spread responsibility of operations in a foreign land.

To the majority of U.S. oil companies working abroad Venezuela is the No. 1 Foreign Area of Promise. It has great oil potential. It is favored geographically and politically. Whether you are already in the country or hope to be, we believe you will find in this issue the best collection of operating articles ever assembled on Venezuelan petroleum activities.

Research on the March

Growth of research facilities gives some indication of the belief that research creates the wheels of progress. Seldom does a month go by without the dedication of new petroleum laboratories.

Both the Sun Oil $2½ million research center, Marcus Hook, Pennsylvania, and D-X Sunray's million-dollar center, Tulsa, Oklahoma, were opened in October. D-X Sunray's laboratory is close to its refinery, where a $10 million addition is under construction.

Joseph N. Pew, Jr., Sun Oil board chairman, said at the dedication: "Our job is to encourage vision as a handmaiden of science through broader education and reduce this to practical invention."

"This research center, in a sense, is dedicated to making our present way of life obsolete," D-X Sunray President R. W. McDowell said. "Our work here will call for us to keep one hand busy improving powerful new gasolines and motor oils... and the other hand busy on research which will make these same new products antiquated."

Free Labor Needs a Policy

Present turbulent labor scene is the natural result of special laws for one segment of our economy. Sylvester Petro, one-time union promoter and now professor of Labor Relations at New York University Law School, presents the situation and suggests reforms in his lucid "The Labor Policy of the Free Society." (The Ronald Press Company, 15 East 26th Street, New York 10. Price $5.)

Will the American people continue to tolerate a condition under which there is one law for a labor union and another for all other forms of voluntary association. Petro holds that Congress acted unconstitutionally when it gave exclusive power to the National Labor Relations Board. He believes the answer lies in abolishing NLRB and returning to regular courts for jurisdiction arising under the National Labor Relations Act.

This volume is "must" reading for industrial relations personnel and on up to top management. It is basic knowledge needed to protect free labor and free institutions.

Capitalism for People

There is considerable generalization on the American economy and an easy acceptance of the term "People's Capitalism." It sounds very democratic.

A panel of men from Yale University and the Advertising Council talked on the subject and finally arrived at these reasons why we have a successful economic system:

1. An "economic ballot box" through the free choice of goods.
2. Widespread supplying of capital through savings, insurance, stocks, etc.
3. Recognition that economic enterprise must be conducted with regard for the public good.
4. Demand for a rising, dynamic way of life.
5. Broad distribution of benefits of the economy among the people through a high standard of living.

These are distinguished and intelligent panelists, but it seemed to us that it took a long time and a lot of words to say what has brought us the highest standard of living in history. We think it is very simply:

Freedom and work.

Prize Annual Reports

Continental Oil Company, Houston, and Texas Pacific Coal and Oil, Fort Worth, received awards for best annual reports in the petroleum industry. In this 17th Annual Survey of *Financial World* magazine, "Oscars-of-Industry" went to Conoco for large integrated companies and to Texas Pacific for small independents.

Creole Petroleum Corporation, New York, and Standard Oil (Ohio), Cleveland, were runner-up and third for large firms. White Eagle Oil Company, Tulsa, and Home Oil Company, Calgary, Canada, were runner-up and third in the independent class.

Halliburton Oil Well Cementing was winner among oilfield suppliers. Runner-up was Dresser Industries, Inc., and third, National Supply Company.

Scientists Still Wanted

Search for scientists and technicians by the U.S. Armed Forces has been intensified since Sputnik. Seniors and graduate students are being interviewed at colleges and universities by U.S. Service representatives. They are wanted in guided missile research.

This is a natural result of Russia's coming in first with the satellite. The increase in demand is also a warning to business and industry to plan carefully for their needs in scientific and engineering personnel. Government requirements in this case are paramount. It means the shortage of trained persons can become acute within the next few months.

Courage of the Wildcatter

Untimely death of I. P. LaRue, Sr., 61 (killed in a hunting accident October 17), recalls his many examples of courage. Of course, he was a wildcatter and courage is the principal ingredient of a successful wildcatter. LaRue's first discovery was in Cherokee County, Texas. After his Pistol Ridge find in Mississippi he went on to wrap up the largest holdings of any independent in that state.

It takes a great deal of daring to stake your money on finding a new oil field but Ike LaRue proved he had more bravery even than most wildcatters. He headed the "Democrats for Eisenhower" in Mississippi last election. If you know anything about Mississippi you can appreciate there are few persons in the United States who could get 56,000 votes for Eisenhower *on the Republican ticket* in the state. And that is what he did.

Not only is the fact a good measure of his courage but also of the confidence and admiration he inspired by those who knew him. Ike LaRue was unaffectedly friendly and generous — a man of great integrity — a man we'll miss.

Research by the Yard

In one of its spasmodic efforts to economize the Federal Government cut funds of the Office of Scientific Research from $16 to $8 million. Later the amount was restored. Perhaps one result of Sputnik.

The whole episode is a perfect example of how not to run your research department. Large or small, research projects must be planned far ahead and personnel must be found and developed if an efficient use of ideas is desired. You can't buy research in any size you want, a carload today, a small package tomorrow. Research is an investment and continuity is essential. Some private companies do a better job than vote-conscious politicians on setting up a research program and following through. Those who don't are wasting their money.

Power in Concentrate

Three hundred employees — about 5 percent of the total working force — succeeded in blacking out Boston newspapers for about three weeks. About half that number — 2½ percent of the working force — blacked out all the Detroit newspapers for a week. There is something radically wrong with a system that permits a handful of people to decide that millions of people cannot read their daily newspapers until their own conditions are satisfied.

— *From Editor & Publisher*

Engineering in Civil Service

The U. S. Civil Service Commission has revised and reissued the announcement of the currently open examination for engineers. This new announcement incorporates examinations for various specialized branches of engineering that were formerly publicized under separate announcements. The engineering positions to be filled are in various fields of work and pay from $4480 to $11,610 a year. They are in various Federal agencies in Washington, D. C., throughout the United States, and in foreign countries.

To qualify for these positions, applicants must show appropriate education or experience in engineering. A written test or certain positions is required of applicants who do not meet the requirements for a degree in engineering. Applications will be accepted from students who expect to complete the required study within nine months.

Information on examinations and application forms may be obtained from most postoffices or from the U. S. Civil Service Commission, Washington 25, D. C.

"Middle East War Unlikely"

The Turkey-Syria dispute is mostly news headlines in the United States and rumors. The two countries have no intention of fighting.

So believes Emile Bustani, member of Lebanese Parliament, who has been in the United States on business.

Bustani is a good representative of his country and of the Arab world. He tries sincerely to be objective; nevertheless, he feels the Israeli government is unfair and that Egypt is being unnecessarily chastised by the United States. (Freezing Egyptian accounts in United States.) Syria, he said, wanted arms from the U.S., which were refused, but the U.S. supplied Israeli with more than it could use. So Syria bought in the only available market — Russia.

A graduate of the University of Beirut (a U.S. school), Bustani has a master's degree from Massachusetts Institute of Technology. Not only is he a popular politician but his firm, Contracting and Trading Company, Ltd., is active in the Middle East. It is building the King's palace in Iraq and a housing project for workers. It represents Oil Well Supply in the Middle East and recently became associated with Southeastern Drilling, Dallas, Texas, and Turnbull and Zoch, Corpus Christi, in SEACAT Drilling Company, a contract drilling firm. First contract is in Iran with the government-held Iran Oil Company.

Benefits Shared

Contribution made by the oil industry to Venezuelan economy under the current so-called 50-50 arrangement was emphasized by Dr. Edmundo Luongo Cabello, Minister of Mines and Hydrocarbons, in this Annual Report to Congress covering operations in 1956:

"Each bolivar ($0.333) of income obtained by the industry in 1956 was distributed as follows:

"27 centimos went for costs of operation, of which 11 centimos were for wages and salaries.

"11 centimos went for depreciation and amortization of investments in concessions, property, plant and equipment.

"31 centimos went for tax payments.

"31 centimos went for return on investment, of which 23 centimos were declared dividends and 8 centimos reinvested in the business.

100 centimos or 1 bolivar.

"In summary, of every bolivar created, the benefits to the nation, including the government's income, totaled 77 centimos."

The Minister pointed out that in the 14-year period from 1943 through 1956, return on investment in the form of dividends averaged 14.17 percent. He also stated that actual division of net profits between private oil companies and the government during that period was 55 percent for the government and 45 percent for the companies.

Referring to the fact 77 centimos of every bolivar generated by the oil industry remains in the country, he commented:

"This suggests that the traditional system of free enterprise . . . is a good one at this time for the national interests. No one can deny, in view of these facts, that the oil industry is in fact the most 'national' of all our industries."

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Gently rising natural gas prices could be held down if Federal Power Commission controls were relinquished, say producers. Prices of gas moving in interstate lines have risen a penny per thousand cubic feet, from an average of 10.1 to 11.1 cents, since 1954. More gas would be placed on the market if producers knew what to expect, say industry spokesmen. Competition of coal, which has checked price increases, may slow further gas price hikes.

★ ★ ★

U. S. storage for crude oil and residual oils have each declined about 2 percent between 1954 and 1957, reports the National Petroleum Council's committee on storage capacity. Storage capacity for clean products (gasoline, kerosine, distillate) has increased almost 19 percent in the same period. Total crude stocks are listed at 226,000,000 bbl in tanks and other facilities, including tankers and pipelines. Of this amount, however, 70 percent was unavailable for consumption, primarily pipeline fill.

★ ★ ★

Reduction of crude oil imports into Districts I and IV is progressing satisfactorily, says Import Program Administrator Captain M. V. Carson. The President's Special Cabinet Committee, however, has had under close surveillance the quantities of refined products and residual oils being imported. If it is found that these operations are being stepped up, Carson says a separate program may be established, similar to that now existing for crude oil.

★ ★ ★

Permian Basin Pipeline Company claims it faces a dilemma in its gas purchasing in Puckett Ellenberger field, West Texas. The subsidiary of Northern Natural Gas Company claims it faces lawsuit from Phillips Petroleum if it follows a recent Texas Railroad Commission order, and similar lawsuit proceedings if it does not follow the order. Commission ordered the line to take gas ratably from all producers in the gas field, although Phillips had earlier obtained a contract to sell its gas to Permian. The commission made its ruling on request of Atlantic Refining that the pipeline take its gas, too. Phillips appealed the ruling to Texas Supreme Court, which ruled in favor of the Commission.

★ ★ ★

Thomas W. Phelps, assistant to the chairman of the board of Socony Mobil Oil Company, Inc., New York, was elected 1958 national chairman of the Oil Information Committee, public relations arm of the American Petroleum Institute, at its quarterly meeting in Colorado Springs, Colorado. Phelps succeeds **M. S. Hauser,** public relations director of The Ohio Oil Company, Findlay, Ohio. Vice chairman elected were: **R. H. Collacott,** public relations director, The Standard Oil Company (Ohio); **Russell D. Karns,** assistant to the president, Pan American Petroleum Corporation; **G. A. Mabry,** manager of advertising and public relations, Humble and Stewart Schackne, public relations manager, Jersey Standard. **Donald R. Waugh,** New York OIC staff, was elected secretary.

★ ★ ★

Alleged conspiracy to prevent shipments of oil through pipelines to the Middle West brought a $32,235,000 suit by Texas Eastern Transmission Corporation against nine barge operating companies, three oil companies and one individual. TET claims violation of the Sherman and Clayton antitrust acts and that the defendants conspired to monopolize transportation of products from the Texas-Louisiana-Arkansas area.

★ ★ ★

Oklahoma Corporation Commission has cited Gulf Oil for contempt for its "purchaser prorationing" practices in that state since August 1. Oklahoma has a rule requiring oil purchasers to take full allotted state allowables. Gulf has failed in several attempts to get a federal court injunction against the Commission rule. The state agency claims it has given exemptions to other purchasers who have asked for them, but says Gulf has ignored the Commission completely.

★ ★ ★

Socony Mobil Oil Company's East St. Louis, Illinois, refinery is now getting back to full operation following termination of a 17-week strike by its 500 AFL-CIO Oil, Chemical and Atomic Workers Union employees. Company spokesmen said workmen returned to work the second week of October with terms of contract settlement near those offered the union early in the strike.

★ ★ ★

The Defense Department, largest customer of the American petroleum industry, notes a shift in its demand for various oil products. Military Petroleum Supply Agency buys about 7 percent of the U. S. oil production. For the first time, MPSA reports, jet fuels got the largest share, accounting for 35 cents of every government oil dollar; 29 cents was spent for aviation gasoline; 8 cents for motor gasoline; 9 cents for distillates; 14 cents for heavy fuels, and 5 cents for lubes and greases.

★ ★ ★

The Texas Company is gathering its "home office" employees closer by constructing a new 16-story building, adjoining the 13-story Texaco Building in Houston. Growth of the firm has forced departments to take quarters in several Houston office buildings. Texaco buildings will extend a block in one direction and be about one-half block deep. Construction of the addition will begin next spring.

1958 Desk and Derrick Officers. Seated, Irma Cline, 1957 president, Nelson, Montgomery, Robertson & Sellers, Wichita Falls, Texas; LaVerne Montgomery, second vice president, Rocket Petroleum, Lubbock, Texas; Maxine Hacke, president-elect, Warren Petroleum, Tulsa, Oklahoma; Ellen Vaughan, first vice president, Carter Oil, Shreveport, Louisiana; Doris Allen, secretary, Skelly Oil, Tulsa; Virginia Adcock, treasurer, Clark Fuel Producing, Mission, Texas. Standing are, regional directors: Regina Glasco, Sun Oil, Tulsa; Lucille Barthlow, Leonard Refineries, Alma, Michigan; Doris M. Weber, International Lubricant, New Orleans, Louisiana; Mary Lee Evers, Monsanto Chemical, Eldorado, Arkansas; Jo Landusky, Velma Petroleum, Hobbs, New Mexico; Virginia Auer, El Dorado Refining, El Dorado, Kansas; Margaret Buckingham, Ohio Oil, Casper, Wyoming; Katherine M. Livada, Tretolite, Los Angeles, California.

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(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

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Sharp increase in domestic consumption during the next three months is predicted by IPAA. Assuming normal weather, the IPAA indicated domestic demand for the period to be from 3 to 5 percent above year ago levels. A 3 percent increase would amount to a total U. S. crude consumption in December of 7,100,000 bbl daily. Average in October was about 6,750,000 bbl per day.

★ ★ ★

Military petroleum purchases outside the U. S. have increased from 17 percent of all oil purchased in 1954 to 27 percent in the fiscal year of 1957, IPAA pointed out to Secretary of Defense Neil McElroy. These purchases were made when increased foreign oil on the domestic market was cutting down U. S. drilling and exploratory activity, the letter stated.

★ ★ ★

Two new antitrust cases have been filed against suppliers — one because the price of gasoline was lowered; the other because the price of gasoline was raised. Federal Trade Commission charged The Texas Company with price discrimination among leasee station dealers in Norfolk, Virginia. The Department of Justice, needled by the Roosevelt Subcommittee of the House Small Business Committee, indicted a South Bend, Indiana, supplier group for conspiring to end a gasoline price war.

Noted oil publisher dies. Ray L. Dudley, president and chairman of the board, The Gulf Publishing Company of Houston, Texas, and publisher of *World Oil*, *The Petroleum Refiner*, *Pipeline Industry* and the *Composite Catalogs*, died in his home in Houston, October 29. He was 66 years old, and had suffered a heart ailment for a number of years.

He left the newspaper field to become one of the early pioneers of oil industry publications when he guided the former *Oil Weekly* to success. Through his continued efforts and hard-hitting ability, he added considerable stature and respect to oil publications. He was a fighter for what he believed in . . . and frequently and forcefully expressed his views in print on controversial matters pertaining to the oil industry as well as government. He was a leader in his field.

Production and exploration activities of Warren Petroleum Corporation were taken over by Gulf Oil Corporation and Warren, in turn, is taking control of Gulf's natural gas plants. More efficient operations are the objective. Gulf has 9 natural gasoline plants and interest in 13 others. Warren has 12 plants and interest in 10 more. Warren's oil properties are in North Dakota, Texas, and Louisiana.

★ ★ ★

Tidelands ownership dispute between the U. S. and Louisiana is responsible for tying up more than $85 million in royalties from oil produced in the disputed area of the Gulf of Mexico. Money will be held in escrow until ownership is decided between the three mile and three league (10⅓ miles) mark. The $85,075,500 accumulated in one year since an interim agreement last October.

Venezuelan Holidays

Holidays change from country to country and you may need to know those of Venezuela. Here they are for 1958:

Month	Day
January	1
April	3, 4, 19
May	1
July	5, 24
November	1
December	25

Employee layoffs have been announced at Indiana Standard's huge Whiting refinery. Involved were 140 of the 8000-worker force. Cutbacks, say officials, are due to reduced manpower requirements and effected only "temporary" employees. Standard also said it was streamlining its general staff in an effort to cut costs.

★ ★ ★

Crown Central Petroleum Corporation of Baltimore, Maryland, is the first new oil importer since the beginning of the voluntary import program. Administrator M. V. Carson said it could import up to 5000 bbl of crude per day. It served notice that it desired to become an importer in March. Under rules set up under the program, only a six-month waiting period is necessary. Carson had increased import allowables of International Refineries and Northwestern Refining Company early in October. Under the new schedule, International may import 12,250 bbl; Northwestern, 13,500 bbl daily.

Ira H. Cram, right, Houston, Texas, senior vice president of Continental Oil Company, was honored by the University of Minnesota for "noted professional attainment" and presented the school's Outstanding Achievement Award for distinguished engineering graduates.

The award was presented to Cram October 4 by President J. L. Morrill of the University of Minnesota at the 19th annual dinner meeting sponsored by the school's Institute of Technology Alumni Association.

★ ★ ★

West Coast pipelines of major oil companies are due for investigation, says the Justice Department. Antitrust suits have been filed that involve control of pipeline facilities. Initial investigations that began late in October concerned pipelines in the rest of U.S., in which several companies were charged with "placing independents at the mercy of the majors."

★ ★ ★

New research center of D-X Sunray Oil Company is now housed in a new $1,000,000 structure in Tulsa, Oklahoma. The building, to be known as the Harry T. Bennett Research Center, is named for the company's technical advisor, who is now nearing retirement. Bennett, a veteran of 38 years of service, received the John Scott award for work in "Stabilization of Cracked Gasoline," in 1950.

★ ★ ★

A 12-day production schedule has been set in Texas for November, despite purchaser pleas that a further reduction is necessary. This is the same schedule as October. Several refiners have indicated that they are able to buy only a portion of state allowables. Wells in Texas are operating on the tightest producing schedule since the proration system was introduced 30 years ago. Other states may "stand pat" for the coming month.

Good Wells Make Good News

November, 1957

WATER is an economical, effective fracturing fluid. It may be gelled or not. Acid may be added for treating acid-soluble formations. A wide variety of addition agents can also be added to combat emulsions, silicate swelling and other formation peculiarities. Here are some recent treatments that illustrate how Dowell engineers use water for successful fracturing under various conditions.

- **Grant County, Western Kansas** (Old Gas Well): This well was completed in the Hugoton series in 1949, and brought-in with 14,000 gallons Dowell X Acid. When deliverability declined to 423 mcfd, the operators decided to plug back into the Winfield zone and fracture the upper zones with Riverfrac*. Dowell performed the service using 80,000 gallons fresh water—*without sand.* Injection rate down casing *averaged 100 bpm. Deliverability after treatment was 1200 mcfd.*

- **Ector County, West Texas** (New Well): This well was completed in tight Clear Fork dolomite with perforations from 5696 to 5736 feet (two per foot). When well would not produce without stimulation, Dowell recommended Riverfrac with acid added. Treatment was performed using 20,000 gallons water with 5,000 gallons concentrated acid added, and 25,000 pounds sand. This was followed by a 20,000 gallon water flush, with de-emulsifying agent added. Injection was down casing at 76 bpm at 1800 psi maximum. *After treatment, well tested 360 bopd flowing. This was about three times the production of similar wells in this pay that had been fractured with oil-base or oil-and-acid fluids.*

- **Alberta, Canada** (Old Gas Well): A well completed in the Basal Quartz sand of the Morinville area had gone to water. When it was plugged back to 4,308 feet, water was shut-off, but gas production was negligible. Dowell was called to fracture with Waterfrac—using 2,100 gallons gelled water and 4,000 pounds sand, preceded by a 250-gallon spearhead of Mud Acid. *After treatment, well tested 30.5 mmcfd open flow and delivered 3.5 mmcfd to pipe line—with no water.*

- **Chase County, Eastern Kansas** (New Well): Open hole completion, 2,278 to 2,287 feet, in the Bartlesville sand near the edge of a waterflood project. Initial test revealed only show of oil. For stimulation, operator selected Riverfrac, using 31,600 gallons fresh water and 25,000 pounds sand. Well was treated down casing at 24½ bpm average injection rate. *60 days later, production had stabilized at 70 bopd.*

Part of the secret of success in using water for fracturing, is the experience of the service company you have perform the service. That's why it is important to specify Dowell. For information on the use of water for fracturing—or for service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

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DR. EDMUNDO LUONGO CABELLO

An Interview with

One man in Venezuela stands in a unique position from which to view both political and operational facets of the country's petroleum industry. He is Dr. Edmundo Luongo Cabello, Minister of Mines and Hydrocarbons.

Trained as an engineer, he understands the industry's technological problems. An intelligent and capable politician with 30 years' experience in the government of the Republic of Venezuela, he knows what the country can expect from oil and gas resources.

Dr. Luongo received his doctorate in physics and mathematics from Central University, Caracas, before he was sent by the government to the University of Oklahoma where he completed his petroleum engineering studies in 1933. His entire career has been devoted to science and engineering and his active work with the ministry has been interrupted only by studies and work in actual oil operations in Venezuela and the United States.

This interview was given in Dr. Luongo's spacious modern office atop one of the twin towers that house government offices at the head of the Avenida Simón Bolívar, Caracas.

An interesting and facile conversationalist, Dr. Luongo speaks excellent English. His answers testify to his grasp of government and industrial affairs.

Keys to Venezuela

RICH CONCESSIONS . . . OUTPUT COMBINES WITH U. S. TO FULFILL NEEDS . . . PEOPLE AND OIL COMPANIES GET ALONG . . . MIDDLE CLASS GROWING . . . BENEFITS FABULOUS . . . RISING INTEREST IN EDUCATION AND TRAINING . . . BRIGHT FUTURE IN THE WORKS

Dr. Edmundo Luongo Cabello

Minister of Mines and Hydrocarbons

Q. Are you satisfied with the results of the opening of new concessions in Venezuela in 1956?

A. We are pleased with the outcome. The new concessions brought in more money. They cost more but operations are not so expensive now as they were at the time of the first concessions. Now there are roads and sanitation. Malaria, for instance, has been wiped out. Many of the hardships have been overcome.

Q. Do you continue studying the possibility of opening new areas?

A. We always have this under consideration. The companies want this and that area opened. We consider the idea. We want a gradual development that will serve the country and will not hold back the progress of either the country or the companies. Right now we don't have any area opened for bidding.

Q. Venezuelan production has been increasing at a more rapid pace than that of the U. S. recently. Do you feel that it is fair to expect some slowdown in the rate of increase here insofar as exports to the U. S. are concerned, to allow the U. S. production rate to catch up?

A. Venezuela stands alone as a historical supplier of oil to the United States, and for this country the availability of such vital commodity has been, more than once, of critical importance. We feel, we rather are sure, that Venezuelan exports, on the other hand, have never interferred with the development of United States domestic oil industry, but rather supplemented it and greatly helped to fulfill United States needs because Venezuelan oil contains high proportions of fuels and asphalts.

Q. What is the attitude of the Venezuelan people toward oil companies?

A. Our people and the oil companies have a mutual understanding and mutual appreciation. Like a coin with two sides — both sides are part of the whole. Together they have value. We approach our problems in a philosophical way. We and oil company people have round table discussions to arrive at the best way of doing things.

For instance, now we are fighting to save gas that is being flared. We can't do it all at once but in time we will succeed. We are making progress every day. Repressuring projects in both Western and Eastern Venezuela are now operating to use gas energy to recover more oil. The new government petrochemical plant will use gas. Refineries are fueled by gas.

Q. Do you feel the people are benefiting directly from petroleum wealth?

A. We have a growing middle class — a strong middle class. It comes from pocket power. Everything that has

Beautiful twin towers mark Simon Bolivar Center. Old buildings were leveled to create a modern commercial center seldom equalled. At top of left tower are offices of the Ministry of Mines and Hydrocarbons.

happened in this country — including revolutions — has tended to sweep away class distinctions. The money from natural riches has built up businesses and services, such as insurance, has brought construction work — new buildings, highways, and dams. All this provides many jobs and builds up the pocket power.

Q. Since you have a private capitalistic economic system why did the government decide to operate the petrochemical industry?

A. To us petrochemical has a new meaning. It is the process to make of our mineral riches a base for many industries. It is a process that gathers up natural resources and turns them into products that will be raw material for private capital to use in building new business.

Q. Will you permit outside capital to establish a factory that uses petrochemical products from your government plant?

A. Under stipulated conditions, yes.

Q. Do you have a government center of research for natural resources?

A. The universities devote much effort to research. Then we have the new atomic energy research project. The government constantly researches plans to transform natural riches to actual riches.

Q. Have you any program for interesting your young people in studying science and engineering?

A. The government educates hundreds of engineers. In the last two or three years the number has doubled and trebled.

Q. How many men on your staff have studied science and engineering in the United States?

A. More than one hundred.

Q. Do you feel the oil companies have a good program for educating and training the young people of Venezuela?

A. The oil companies have done an excellent job of that. You see our young people at all the companies. They have on-the-job training and many are sent by the companies to universities both here and in the United States for further engineering and technical studies.

Q. Speaking of your young people then, you might say you have a lively and progressive future ahead?

A. We feel there is a great and rich future in store for Venezuela and for Venezuelans.

Ernestine Adams

VENEZUELA

—Land of the BIG BOOM!

Modern version of fabled El Dorado brings explorers to search for riches in oil and iron and gold . . . Astute Venezuela shares the wealth

ROME wasn't built in a day, but Venezuela doesn't know it. She is pushing pell-mell into every avenue of economic and social progress. The country is probably moving faster than any other nation in the history of the world.

Modern cities rise in tropical jungles, and these carpets of primeval forests in turn wither before a blaze of modern commercial and cultural pursuits.

Venezuela is a young country in a hurry.

The bulldozer is a good symbol for modern Venezuela. It flattens slums and decadent colonial mansions alike and smooths the foundations for brightly painted streamlined apartments where a middle class can take hold and grow.

It plowed a road up a mountain to build the most spectacular playground we have seen — a recreational center above the clouds reached by cable car. On an adjoining peak is the luxurious Humboldt Hotel, a circular shaft of glass that overlooks Caracas on one side and mountains and seashore on the other.

The bulldozer so determinedly gnaws away at so-called impenetrable jungles that good highways disturb the rattlesnake and the jaguar, and ancient abandoned haciendas are uncovered.

Miss Adams is Management Editor.

"We have the richest country in the world," a young Venezuelan declares matter-of-factly. It could be — for its size — the richest nation. And today its potential has only been glimpsed.

Its History

When Columbus discovered Venezuela on his third voyage it is small wonder that he thought he'd found the Garden of Eden.

The next year in 1499 another Spanish explorer, Alonso Ojeda, called the country Venezuela — Little Venice — because Indians in Lake Maracaibo lived in huts set on piles and paddled their dug-outs through hidden canals.

Another tribe of Indians — the Achagua — set off the wildest hunt of all — the search for El Dorado. Venezuela was largely settled in those early days by bold adventurers who pushed into jungle-wrapped mountains to find the city of gold and jewels.

And why not? Nature itself is dramatic in Venezuela. You can look at the cloud-covered Andes and easily believe in a city of shining gold.

The fact is — you would be right. For El Dorado was there — disguised and waiting for 20th Century explorers. It was dark and liquid and below the surface. It was carmine and metallic and imprisoned in mountains. It waved tall and green on the llanos. It was wealth more valuable than gold.

— Courtesy Shell

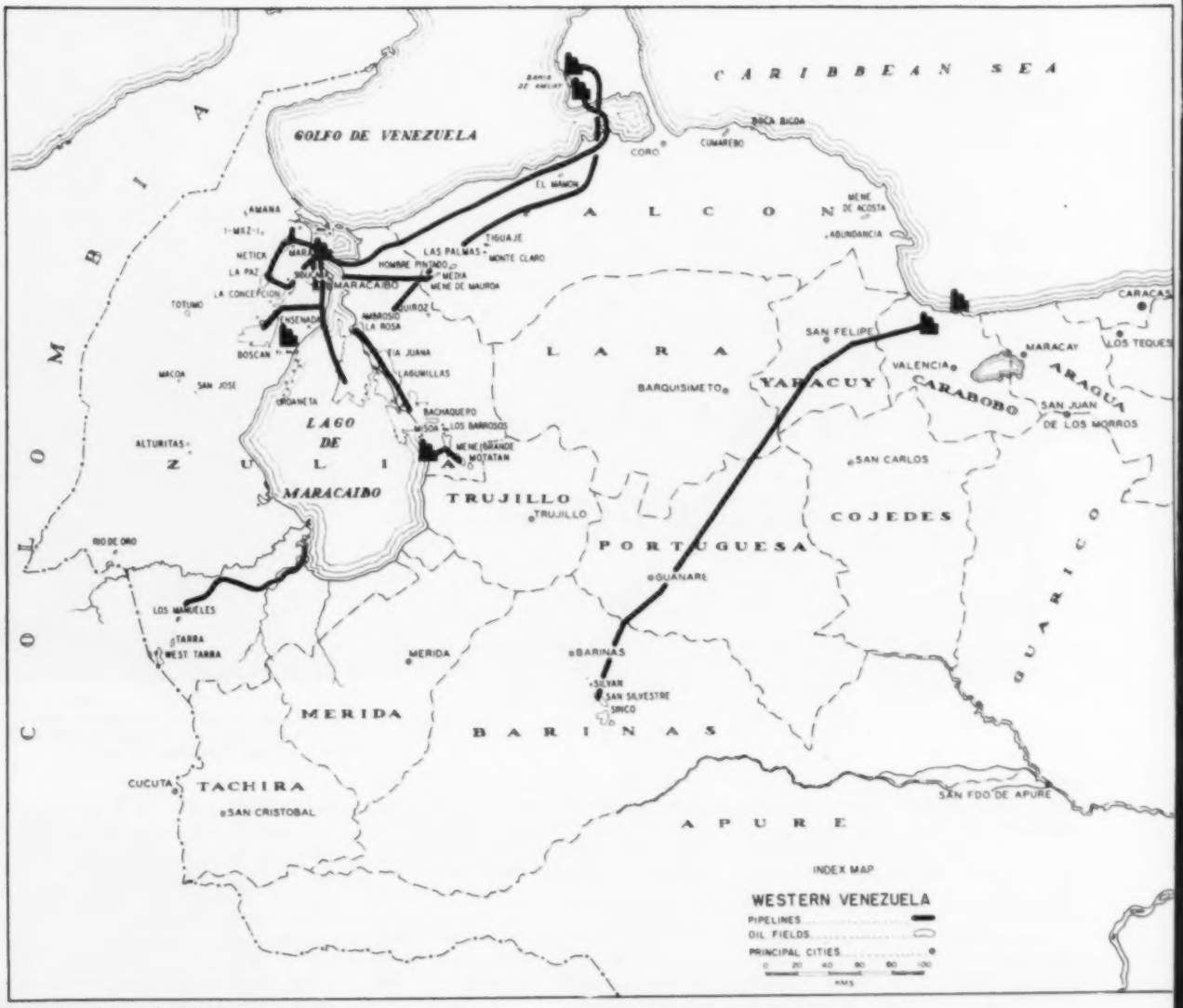
First commercial oil well in Venezuela. It was Shell's discovery of Mene Grande field, east of Lake Maracaibo, in July, 1914.

Its Politics

Venezuela was the first Spanish colony to win its independence from Spain. Under the leadership of Francisco de Miranda and Simon Bolivar it was declared a confederation of free, sovereign and independent states on July 5, 1811. They had tried to make it July 4 — on the same date as the United States. Eleven years of civil war followed until 1821 General Bolivar finally subdued the Royalists.

Bolivar's dream of a South American Confederation died in its infancy. Venezuela broke away from the Colombian Federation in 1830 and set up her own Republic. She went through turbulent times, often preyed upon by political grafters until the treasury was empty and sales of national bonds abroad brought only a pittance to the State.

Then in 1908 came Juan Vicente Gomez, the shrewd and savage mestizo of the Andes. For 27 years he operated Venezuela like a country store, picking up anything in the nation that pleased his fancy for himself and his family and friends. Opposition could buy only torture and death. Gomez did, however, content himself with plundering his own country and did not bring the havoc of war and pestilence that other 20th Century dictators inflicted on their nations. He paid off Venezuela's



Note: Boundaries of oil fields are approximate. These maps are from Creole Petroleum Corporation.

OIL OPERATIONS IN WESTERN VENEZUELA

international debt and invited outside capital to come in and seek a modern El Dorado.

Gomez put Venezuela into a political deep freeze. When he died in 1935 confusion reigned although men wore the presidential insignia.

In 1948 a three-man military junta ousted Romulo Gallegos, a popular novelist but evidently no politician, in a bloodless coup. In 1952 President Marcos Perez Jimenez took office, beginning a term of what is considered the most spectacular economic and social advance this country or any other ever witnessed.

Its Geography

Before we get into today's picture of Venezulea, let's see what nature gave her.

Shaped like a roughly scalloped triangle standing on its blunted apex, the lands and water of Venezuela embrace unending variety. And this is true even though exploration of the country is only really only beginning.

Entirely in the torrid zone, temperatures are moderate to cold in large portions because of the elevation. Only along the coast and in the llanos is the climate tropical.

The great Orinoco River with its tributaries drains four-fifths of the country. Second only to the Amazon in South America it is 1600 miles in length and is navigable for 700 miles.

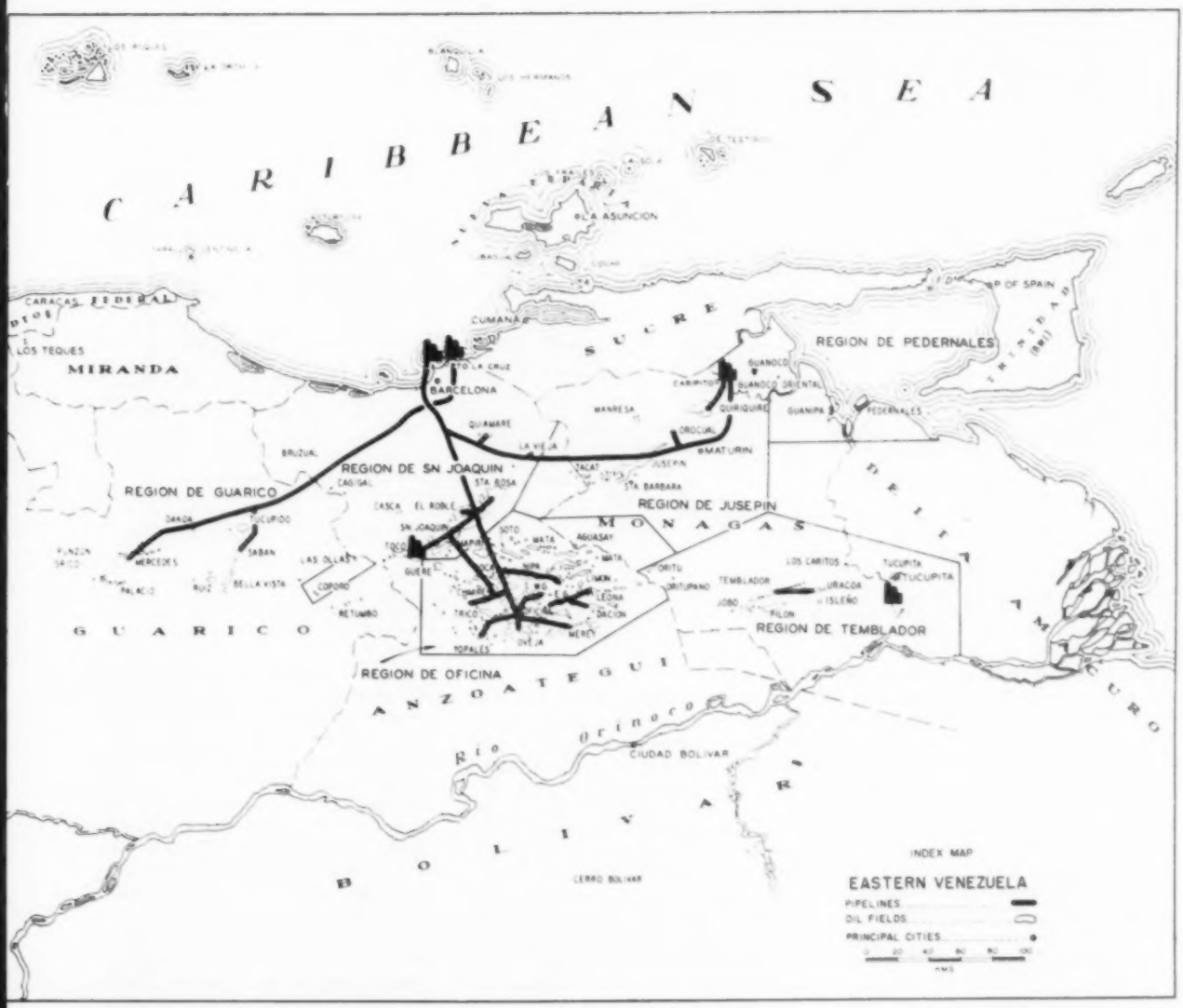
The country falls into four distinct regions.* The mountain zone in the north, which includes two spurs of the great Andes range, contains the most populated areas. The temperate climate is inviting and the beauty of the mountains is alluring not only to people of the fabulous capital city of Caracas, close to the north central coast, but also to the fierce Motilon Indians in the extreme west.

The coastal zone is small. Along much of Venezuela's long coastline, its mountains plunge directly into the sea. At other spots — like La Guaira — the port nearest Caracas — a town huddles on a narrow strip of coastland and leans against the mountains.

In the west coastal zone is oil-rich Lake Maracaibo with the Gulf of Venezuela set above. Together they make a slightly melted hourglass. The government spent $35 million (financed by bonds) on a channel so that big oil tankers could move between the two bulbs of water.

The llanos, south of the mountains,

*"Petroleum Geography of Venezuela," by Dr. Guillermo Zuloaga is the chief reference for this section.



Note: Boundaries of oil fields are approximate. These maps are from Creole Petroleum Corporation.

OIL OPERATIONS IN EASTERN VENEZUELA

are great plains covered with coarse grass, running the breadth of the country. Here the wet and dry seasons swing from flood to drouth. Cattle raising is making room for more diversified agricultural development. Near Calabozo (south of Caracas) a 10-mile dam on the Guarico River stores waters to use for irrigation on small farms.

The fourth region is the scarcely touched Guayanan Hinterlands. Comprising almost half the nation, it is inhabited mainly by nomadic Indian tribes. But these are like no other Indians. They live on the sale of gold and diamonds, panning for them in mountain streams.

It is also in this zone that the great "mountains of iron" were found—some 600 million tons of ore that tests up to 69 percent metallic iron.

In the magnificent Gran Sabana of this region (southeast) are lofty peaks and waterfalls of rainbow beauty. Angel Falls (about halfway between El Pao and the Brazil border) is the highest in the world. It is 15 times higher than Niagara Falls.** A national preserve in this area was announced last month by the government.

Its Resources

Venezuela's most important natural resource is petroleum. Largest exporter of oil in the world, it sells abroad about 2½ million bbl a day.

Last year total government revenue tipped $1.4 billion for the first time. The oil industry provided almost $1 billion of this; approximately one third was for concessions payments.

Only a limited portion of Venezuela's possible oil lands are now under contract by oil companies. The entire country has 91 million hectares† with 40 million, almost half, considered potential petrolific areas. Up to the present time, exploration and exploitation concessions cover less than 7 million hectares.

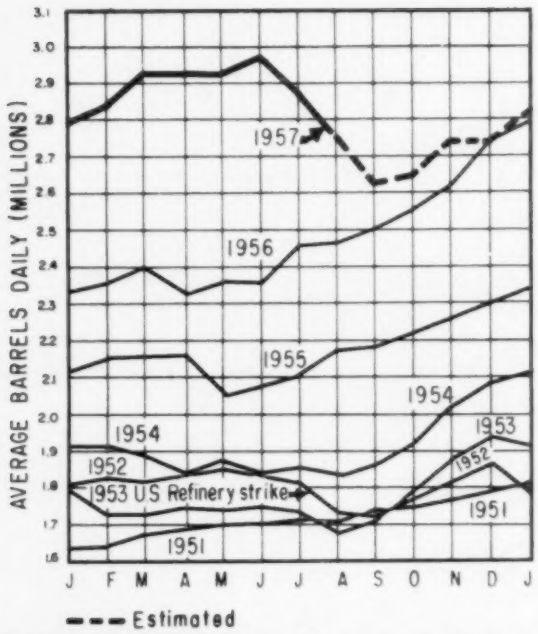
In Venezuela Bethlehem Steel and U. S. Steel's iron ore discoveries are said to be among the richest finds ever made.

Bethlehem Steel works on its concession at El Pao, northeast Bolivar State, from where the highest grade of ore (up to 69 percent metallic iron) is taken on a railroad to the Orinoco and down the Gulf of Paria.

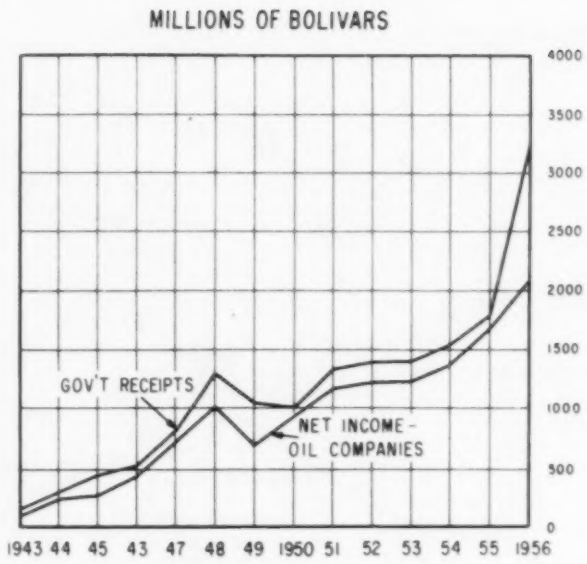
U. S. Steel opened up a whole section of the country to get to its vast mountain of iron, Cerro Bolivar, 75

**"Jungle Journey to the World's Highest Waterfall," by Ruth Robertson, National Geographic.

†One hectare is 2.4711 acres.



Venezuela production has jumped in recent years. Slowdown in demand as much as U. S. import regulations caused drop in last half of 1957. Suez crisis helped rise earlier.



Government and companies divide income from oil operations. Sharp rise in 1956 is due to bonuses from new concessions offered by government.

miles southwest of the junction of the Orinoco and Caroni rivers. The deposit is estimated at 500 million tons of ore.

Pockets of gold near El Callao, an old and famous mine, continue to be found. Production in the last two years is reported to have doubled and a new company opened a gold plant that can process 24-karat gold.

Diamonds found in mountain streams of the Guayana contribute to the economy. Of good quality, about 94 thousand karats were marketed last year.

Uranium deposits discovered are the largest in Latin America.

One problem of Venezuela is producing enough food within the country. Until recent years the standard of living was low enough to be supplied by domestic crops. Now the country has outgrown its food industry.

So agriculture research is intense and business-like. It has produced results. For instance, cattlemen from Tachira State went to Texas this spring and brought back 500 heads of Brangus (Brahman and Angus) cattle for breeding stock. Production of beef, butter, milk, cotton, and sugar increased in 1956 over 1955. Figures were not out on coffee, a major crop, cacao, corn, tobacco, etc.

In April the first shipment of Venezuelan shrimp went to Florida hotels to begin a new export business.

Venezuela proceeds energetically to develop and enjoy her resources—at home and in the trade for the things she wants and needs.

Its Projects

From oil and other resources comes a golden flow into the treasury. Where does it go, and who benefits?

A good share of it goes for capital investment in the biggest public works program ever undertaken by a Latin American republic. Last year 57.11 percent of the country's revenue was spent on national projects.

Highways reach into the towering Andes on the west and across the central grasslands—the llanos. Towns imprisoned by tropical jungles and roaring waters are freed by asphalt links that tie them with the modern world. Venezuela has the best transportation system on the continent—some 15,000 miles of highways—and its program keeps the bulldozer busy clearing the land for more. Roads and bridges and tunnels have shortened distances and, in the American tradition, put new cars on what some call the "essentials-of-life" list.

The most imaginative of the transportation projects is a $99-million bridge to span the Lake Maracaibo narrows near the port of Maracaibo. It will provide direct land communication between the isolated city and central and eastern Venezuela. A German combine has the construction contract. The bridge, 5½ miles long, will require three years to build. The central span will allow passage of large tankers. On the bridge will be two dual-lane roads separated by a railroad track.

A continuing program that works like plastic surgery on the towns and cities is the anti-slum project. Hovels are torn down and for their dwellers, cheerful, modern apartment houses are built. They are grouped together and include conveniences of a regular community.

Imagine the "December 2" project! (Named for its dedication day). Last year 22 apartment buildings, some as high as 15 stories, were added to a group of 13 apartment structures built in 1955. This Caracas project

DRILLING, RESERVES AND PRODUCTION IN VENEZUELA.

	1952	1953	1954	1955	1956
Wells drilled					
Exploratory	114	134	170	171	138
Outstep	249	301	271	302	452
Development	964	536	395	690	859
Total	1,327	961	836	1,163	1,449
Gross increase in proved reserves (million bbl)	818	1,573	1,472	2,283	2,241
Total proved reserves at end of year (million bbl)	9,221	10,152	10,932	12,429	13,951
Total production (million bbl)	660.2	644.2	691.8	784.4	899.2
Reserves as No. of years' supply	14.0	15.8	15.8	15.8	15.5

Source: Ministry of Mines and Hydrocarbons

houses 17,000 persons, has 68 stores, one supermarket, schools, playgrounds, three nurseries for working mothers, one church, two gas stations, and an administrative building.

Apartments rent for $24 and $57 monthly or they may be purchased outright for $1500 to $4000 on terms of 10 to 20 years.

This is the largest project in the housing program, but there are many others. In Maracaibo the buildings are three-story with six apartments, but one project has 38 apartment houses.

Greater water resources were needed for the growing city of Caracas — which already has more than a million population. The Tuy river was dammed and its waters turned into the Caracas aqueduct.

The Guarico River dam is completed and the irrigation system put to work. Now farmers can buy land in the irrigation area.

Tourist hotels of splendor and luxury are being constructed with government money. Some $55 million was spent on 16 hotels for tourists and to stir up interest among its people to "See Venezuela First." Venezuelans are hardy travelers and have a penchant for seeing every country except their own. The hotels are strictly commercial and expected to pay out like most government investments. Administrators of this enterprise were sent to Cornell University hotel school for training.

A contract has been let to construct a steel mill of 1.2 million-ton annual capacity. The Italian Fiat group will begin work in the spring of 1958. Cost is estimated at $142 million.

The Venezuelan Petrochemical Institute has begun construction of the first petrochemical plant at Moron, 15 miles west of Puerto Cabello. A fertilizer plant and a sulfur extraction plant have already been built. A small 3000 bbl per day refinery was constructed to supply some needed material.

The Venezuelan Institute of Neurology and Brain Research is constructing an atom reactor plant to be completed in 1958 at a cost of $3.6 million. General Electric will build it.

For all its aggression on the economic front, the government shows no inclination to get into business unless a vacuum exists.

Apartments are rented and sold on the payment plan. Hotels built by the government are expected to pay. The Caracas-La Guaira superhighway has in three years collected $9.5 million in tolls.

Other business projects are frankly speculations that a rich country can afford to make. The goverment is financing the petrochemical plant because private capital is probably not available for a business with such uncertain returns.

— Courtesy Creole

Modern architecture holds sway in Caracas. Here are superblock buildings for middle class housing, constructed by Workers Bank.

The government prefers collecting taxes to running business and industry.

Its Health and Culture

Economic strides have been matched by social advancement.

Health, education, and the arts are fed by wealth from national resources.

Health and sanitation are stressed by the government. A nation-wide system of preventive medical treatment has been established. There are 21,788 hospital beds in the country, double the number 10 years ago. Graduate doctors from Venezuelan medical school have increased the number of physicians by 50 percent in five years.

Medical, surgery and hospital services in government-supported health institutions are free to the very poor, are billed to Social Insurance Administration for regular workers, and are paid individually by others.

Infant mortality has steadily declined and the birth rate has increased. Smallpox, an ancient scourge brought from the Old World, has been virtually destroyed. Malaria, which dehabilitated the people of Venezuela for centuries, has been brought under control. Venezuela has had a drop in general mortality rate from 13.5 for 1000 population in 1947 to 9.6 in 1956.

When Dr. Luongo* said the new companies in Venezuela did not have some problems of earlier operators, health was one of the specific items he mentioned. You can't very well fight malaria and hunt oil deposits at the same time, although many have tried.

Schools have trebled in five years. The government has set out determinedly to wipe out illiteracy. Distinguished seats of higher learning are Central University, Caracas, and National University of Zulia, Maracaibo. Exploration interest drew university personnel and U. S. scientists into a scientific expedition for archeology and other studies early this year.

In August an exhibit of modern Venezuelan architecture was exhibited in World Affairs Center, New York. It told the public what several individuals had declared—that Venezuela is in the forefront of modern architecture.

The Venezuelan symphony orchestra is one of the best. Art galleries and museums get deserved attention.

A total of 470 books were published in Venezuela in 1956. There are five Spanish dailies in Caracas alone and one English daily, Caracas Journal.

An excellent magazine in English is published monthly by the Venezuelan Embassy in Washington—"Venezuela Up-to-Date."

Its Economics

President Perez Jimenze of Venezuela said in a speech during the celebration of National Week:

"We have . . . become a nation with a philosophy based on real values with abundant favorable results.

"This is evidenced by the completion of projects for roads, communications and transportation, agricultural development, electrification, creation of basic industries, increased teaching facilities, scientific advancement, and expansion of human reserves, all in an atmosphere of sound peace.

"It is equally demonstrated by the prominence enjoyed by Venezuela in international congresses, conferences

*Dr. Edmundo Luongo Cabello in "Keys to Venezuela."

— Courtesy Creole

Bridge on Autopista highway which joins the seaport La Guaira with Caracas, the federal capital, 10½ miles away. Six lanes wide, it cost $69 million.

and exhibitions; by the credit given her for ever surpassing economic, sanitary, housing and road building records; for the stability and soundness of her currency; for the business credit enjoyed in foreign markets, and the recognition of her support to every principle of human solidarity, the mention of her name in important world circles, and by the thousands of persons who come to her territory in search of peace and well-being."

It is a surpassing record and well substantiated.

The Venezuelan bolivar (about 30 cents) is hard currency, respected any place in the world. The national budget is not only balanced, it has a surplus and—wonder of wonders—no debt!

Government 1956-57 fiscal operations resulted in a surplus of $574 million, increasing treasury reserves to a record $783 million on June 30. Its gold reserves are the largest in South America.

The nation's population has topped 6 million and is growing at the rate of 3.6 percent a year, making Venezuela the fastest growing country in the world. In spite of population rise, per capita income was $850 in 1956, compared to $250 for the rest of Latin America.

Its Relations . . . With United States

Venezuela and the United States are good friends. In principle they agree politically. They depend upon each other economically. Both have free education, compulsory in lower grades, and freedom of religion, although the Catholic Church is the State church in Venezuela.

The Spanish-speaking Venezuelans are better linguists than English-speaking North Americans, but they have other things in common. Individuals are independent but friendly. As nationals they are inclined to let each other work out their own problems. A few perennial U. S. reformers apparently can't resist giving advice—free and without economic aid—to Venezuela. But Venezuelans are too polite to follow the same course.

Most Venezuelans feel particularly close to Southwestern United States where they have kindred feeling for another land of cattle and oil where there is also a search for agricultural diversification.

The oil import-export problem has recently been a fly in the friendship. Much of it caused by misunderstanding. Generally, Venezuelans know only that the United States is cutting down imports of their country's oil and they feel it is unfair because the money they receive is left in the United States to exchange for goods.

In the first six months of 1957 United States exports to Venezuela rose to $454 million, an increase of 35 percent over 1956. This was led by machines and vehicles.

Petroleum exports from Venezuela to United States amounted to $346 million in the first five months which was 77 percent higher than the previous year because of the Suez crisis. Total United States imports from Venezuela reached $394 million in the first five months.

A study released by Econometric Specialists, Inc., a research firm, for Creole Petroleum Corporation, found that in 1956 United States goods and services sold to Venezuela passed the billion dollar mark.

This included $650 million in trade goods and $500 million in "invisible" exports. The intangibles named are services performed by United States banks, insurance firms, shipping companies, air lines, etc., and profit remittances from companies investing in Venezuela.

Venezuela's people have little opportunity to learn the problems faced by the United States oil producer: The struggle to balance supply and demand with conservation as the scales; higher costs of domestic exploration and drilling that send operators to Venezuela for the first time.

For their part, U. S. domestic producers actually center their most intense opposition to imports of Middle East crude. Nor do some in the United States understand that the bulk of Venezuela's exports to United States is fuel oil, which United States refiners would find uneconomic to process from high grade domestic crude.

In the last few years Venezuela's imports have climbed steeply. The years ahead promise still further increase. And the United States is Venezuela's major trading partner.

. . . With South America

In South America the people are more interested in Venezuela than in any other country.

"How is it in Caracas?" asks one.

"Is Caracas as magnificent as they say?" another wants to know.

There are hundreds of questions and they wait eagerly for the answers.

Here is one of their own neighbors who has made good. There may be some envy, but on the whole, the story of success is a thrilling tale worthy of much telling.

The success of Venezuela comes not only from her actions but also from her example. ★ ★ ★

Estimated Inland Consumption of Oil Products in Venezuela Indicates Rise in Living Standards. (Thousand barrels.)

	1952	1953	1954	1955	1956	% change 1955/56
Gasoline	7,250	8,200	9,250	10,400	11,450	+10.1
Kerosine	2,100	2,350	2,600	2,800	3,050	+ 8 9
Gas-Diesel oils	1,650	1,900	2,150	2,600	2,950	+13.5
Fuel oil	3,000	2,450	2,400	2,200	2,100	— 4.5
Other	1,150	1,000	1,100	1,450	1,700	+17.2
Total	15,150	15,900	17,500	19,450	21,250	+10.4

Petroleum reservoirs belong to the nation but are developed by private capital . . . never by companies in which other governments participate . . . Free exploration permitted

Why Venezuelan Laws Draw Outside Capital

Interview with

Dr. Carlos Pérez de la Cova

Minister Counselor for Petroleum Affairs

Dr. Carlos Pérez de la Cova is a graduate of the Central University of Caracas in civil engineering, specialized in petroleum engineering at the Universities of Oklahoma and Tulsa.

He is one of the founders of the Technical Petroleum Department of the Government of Venezuela and was petroleum inspector in various oil fields in Western Venezuela (Maracaibo). On two occasions he was Director of Hydrocarbons in the Ministry of Development from which the Ministry of Mines and Hydrocarbons was later created. Later as head of the Technical Department of Concessions and Cartography of the Technical Bureau of Hydrocarbons of the same Ministry, he was a member of the Presidential Commission which studied and drafted the present hydrocarbons law.

From 1945 to 1950 he was a member of the staff of Phillips Petroleum Company in Venezuela, where he served as chief of the land department and member of the operating committee.

In 1950 the Venezuelan Government appointed him Counselor of the Embassy of Venezuela in Great Britain, with the rank of Minister. In 1952 he was transferred to the Embassy of Venezuela in the United States as Minister Counselor for Petroleum Affairs, in which capacity he is still serving.

Since 1951 he has been a member of the Permanent Council of the World Petroleum Congress, and has been a member of the Venezuelan Delegation to the III and IV Petroleum Congress which were held in The Hague and in Rome, respectively.

He represents the Ministry of Mines and Hydrocarbons at the meetings of the Interstate Oil Compact Commission and is a member of the engineering committee of said Commission. He is a member of the "Colegio de Ingenieros de Venezuela" (College of Engineering of Venezuela) and of the Institute of Petroleum of London.

Q. For the benefit of our technical readers I would like to ask you several questions related to the main features of the Law of Hydrocarbons of Venezuela. I know it is considered one of the best petroleum laws of the world and has served as a pattern for some other countries.

What is, in your opinion, the basic principle of the Law?

A. Petroleum legislation of Venezuela, developed throughout many years of experience into the present law, is founded on the system of free enterprise and the institution of private property. Venezuela believes in those principles, and has found it convenient and practical for her national interest to explore and develop her oil resources through concessions awarded to private companies, technically and financially capable of carrying out their legal obligations under the supreme vigilance of the State.

To answer directly your question, I must mention that the basic principle of the Venezuelan Petroleum Law is that the oil reservoirs in the subsoil belong to the Nation. The legal structure of the Venezuelan petroleum activity is based on the constitutional principle that the administration of hydrocarbons falls within the province of the National Executive Power. Hence, all petroleum legislation is national in scope and the states and municipalities are prohibited from enacting laws on the subject.

Q. Does the fact that Venezuela believes in the system of developing her oil resources by foreign companies mean that the Government of Venezuela cannot exploit directly the oil resources?

A. The Constitution of Venezuela provides very clearly that no monopolies shall be granted, and that the Government only may grant concessions for the development of natural resources, for a limited period of time, in the most advantageous conditions for the Nation. Although the prevailing method in Venezuela for the exploration, development, refining and transportation of hydrocarbons, is the system of concessions granted by the Government, the Law of Hydrocarbons empowers the National Executive to exercise directly the exclusive rights to carry out such operations.

Q. You have heard criticism, no doubt, from some people who do not believe in the development of oil resources by foreign capital.

A. In my oninion there is no basis for such criticism insofar as Venezuela is concerned. Those critics claim, in general, that the granting of oil concessions to foreign companies constitutes a sell-out to powerful oligopolistic interests.

We believe, in Venezuela, that a nationalistic policy which prevents the development of the oil resources by private capital would be detrimental to the economy and welfare of the country.

We also believe that a healthy and successful development of the oil industry of those countries with nationalistic

policy is handicapped by political expediency and economic burden.

State operations in a country like Venezuela, with an oil output over and above its domestic needs, would have to face keen competition in the world markets with large and powerful commercial enterprises, which would also involve world-wide transportation and marketing facilities.

Q. What is the juridical structure of the Venezuelan Petroleum Law?

A. The juridical structure of the Petroleum Law is that accepted as the most modern and recent tradition in petroleum legislation, i.e., the granting of a concession is a unilateral act of the State, within its discretionary power, and which is initiated by the request of the applicant; therefore, the title to the concession — although granting well defined and immutable rights — has not the nature of a contract. Exploration, exploitation, refining, and transportation of hydrocarbons, are declared by the Law of Hydrocarbons to be of public utility.

Q. What does that concept of public utility you mention really mean?

A. The declaration of public utility in the Law of Hydrocarbons regarding activities of the oil industry, permits it to be preferred to any other activity less useful to the community or only of interest to an individual or group of individuals.

The most important practical effect of this declaration of public utility is in connection with the establishment of easement rights on private property, the temporary occupation or expropriation of lands needed in the performance of these activities or in the full exercise of primary rights.

This concept of public utility thus becomes a legal instrument to achieve improvement of the welfare of the country by the development and exploitation of its natural resources.

Q. Is there any preference for Venezuelan companies over foreign companies?

A. Corporations, including those of foreign origin, are recognized as legal persons capable of acquiring concessions, regardless of the nationality of their investors or directors. Foreign companies are not debarred from engagement in any type of business open to Venezuelan companies, except that foreign capital may not predominate in coastwide shipping and domestic air transportation. Foreigners and foreign companies are, of course, subject to laws, regulations, and government policies which apply to the conduct of their particular activities. Venezuelan Law places no limitations on the investment of foreign capital in commercial or industrial enterprises.

Q. In view of the fact that the oil industry in some countries has been nationalized or expropriated, could you give me the official thinking of the Government of Venezuela in this respect?

A. The governing principle of the policy of the Venezuelan Government with regard to nationalization of private enterprises in general, and of foreign enterprises in particular — an issue of vital interest to foreign capital and prospective investors — is that property or property rights may only be expropriated in the public or social interest with prior indemnity and due legal hearings in accordance with the provisions of a special law.

With respect to the oil industry, the policy of the Venezuelan Government is amply defined and decided, as I mentioned before, in an endeavor to develop the oil resources within the traditional system of free enterprise, and respect of private investment — a system that has stood all scientific analysis and all practical tests.

Actually, in Venezuela, its present system is a practical application — through the instrumentality of the laws — of two basic concepts, viz., national sovereignty and business statesmanship.

Q. Can any foreign government directly or through a mixed company participate in the development of the oil industry of Venezuela?

A. No. The Law of Hydrocarbons of Venezuela explicitly forbids any foreign government or subordinate agency or companies partly owned by a foreign government from acquiring oil concessions in Venezuela. This provision, traditional in our petroleum legislation, provides a safeguard for the national interest by preventing our natural resources from falling into the hands of foreign powers with all the detrimental consequences to the sovereignty and security of the Nation.

By this provision, political interference in the administration of the strategic resources of the country by a foreign government or international claims is prevented.

It is worth mentioning that the registration of a foreign company in Venezuela brings it within the jurisdiction of the Courts of Venezuela.

Q. Can anyone carry out exploratory activities in Venezuela prior to the acquisition of concessions?

A. Under the present Law, geological and/or geophysical exploration may be undertaken, subject only to certain minor formalities: Notice in writing must be given to the Ministry of Mines and Hydrocarbons at least 15 days prior to the date when the exploration work is to be effected, indicating the approximate area of the zone to be explored.

Free exploration may be carried out on all of the national territory, excepting areas covered by existing concessions. Core holes or shallow wells can be drilled but only to a depth of 328 feet.

Q. You mentioned before that the Government may grant concessions for a limited period of time. Would you elaborate on that?

A. To answer that question I must say that there are four types of concessions, namely:

1. *Exploration concessions* give the exclusive right to explore certain plots of approximately 25,000 acres for three years. This type of concession includes the inherent right to select up to one-half of the plot for a subsequent exploitation concession for 40 years after the exploration period. The other half reverts to the Government as national reserves.
2. *Exploitation concessions* may be granted independently of an exploration concession, for a period of 40 years; however, the Law provides the right to obtain, once only, a new term which cannot exceed 40 years. Because of the constitutional clause that provides that the concession for the exploitation of national resources may only be granted for a limited period, the extension cannot be granted more than once.
3. *Refining and 4 Transportation concessions* may be accessory to, or independent of, those for exploration and exploitation. These types of concessions are granted for a period of 50 years, and are renewable at the holders' option for additional periods of 50 years.

Q. What kind of taxes are imposed on the exploration and exploitation of oil?

A. Taxes are imposed at each step of the development of petroleum production as follows:

Exploration tax of 2 bolivares* per hectare ($0.27 per acre) per year during the period of exploration.

Initial exploitation tax of at least 8 bolivares per hectare ($1.05 per acre), comparable to a bonus and paid only once, on all exploitation concessions, whether resulting from a previous exploration concession or granted directly on open acreage or national reserves.

Annual surface tax, corresponding somewhat to annual rentals as known in the United States, is charged on a graduated scale from date the concession becomes legally valid, as follows: 5 bolivares per hectare per year ($0.65 per acre per year) during the 10 first years, rising to 10 bolivares per hectare per year ($1.31 per acre per year) during the following 5 years; to 15 bolivares per hectare per year ($1.96 per acre per year), and so on until after 30 years it is 30 bolivares per hectare per year ($3.93 per acre per year), but does not increase above this. Increasing scale of this tax tends to eliminate purchase of a concession for speculation by those who have no intentions of carrying out development work.

A production tax, comparable to royalty in the United States, is established in the Law at a minimum rate of 16⅔ percent of the value of crude oil production. This production tax is payable in kind or in cash at the selection of the Government. When paid in cash the tax is based on a formula mutually agreed upon between the company and the Government, for evaluating the market value of oil.

It is to be observed that after the 10 first years of the concession, total royalty payments made by a company on all of its concessions during one quarter is deductible from the amount of surface tax due for the following quarter on the same concessions, but in no case may the surface tax be reduced by this manner to less than 1.25 bolivares per hectare per quarter ($0.65 per acre per year). Purpose of this provision is to encourage active exploitation, as the increasing rate of surface tax after 10 years also increases the burden of a laggard concession holder.

A transportation tax is levied on oil transporting concessionaires of 2½ percent of the amount received for the transporting services.

Q. Are all concessions granted on the minimum rates set forth in the Law, or is it permissible to increase those rates in the bids for concessions?

A. Rates set forth in the Law are minimum rates. A special provision of the Hydrocarbons Law of Venezuela authorizes the Government to stipulate special advantages or considerations to the nation with any prospective bidder.

This special advantage or consideration may consist, among other things, in an increase of the minimum royalty or taxes set forth in the Law, and in the obligation to increase the refining of the production in the country.

For example, in the recent granting of concessions, initial exploitation taxes or bonus over $2000 per acre on some concessions were paid; likewise royalties of 20 percent or over were offered on some concessions.

Q. Can you tell me how the so-called 50-50 principle is applied to the oil industry?

A. Actually the oil industry is subject to three different taxes under the Income Tax Law:

1. *Base or normal tax* — a flat 2.5 percent assessment on net income.
2. *Surtax* — levied at progressive rates increasing with size of income commencing with 1.5 percent on net taxable income up to 10,000 bolivares and reaching a maximum of 26 percent on amounts in excess of 28 million bolivares.
3. *Additional tax*, which is actually the so-called 50-50 profit sharing principle.

The first two taxes are applicable to all commercial or industrial enterprises, and the third is only applicable to the petroleum and mining industries. The additional tax is based on the principle that the oil industry exploits an irreplaceable natural resource and, therefore, the nation must obtain at least a benefit equal to that of each company. The additional tax requires a 50-50 split of the company net income with the Government, provided the previous taxes (including royalty) have not brought about such equalization.

Q. Is the oil industry of Venezuela subject to regulation of production on the basis of conservation as it is the case in the United States?

A. The problem of conservation in Venezuela has two phases: (1) Conservation of oil and (2) conservation of gas. In a strict legal sense the State does not intervene in the economic aspect of production, in relation to the conditions of supply and demand. However, production of oil in Venezuela is governed, in general, by three main factors:

a. National interest of Venezuela as it concerns the economic development of the country.
b. Demand of national and world markets.
c. Strict application of the principles of conservation of oil and gas as provided by the Law of Hydrocarbons and its Regulations.

Q. What are the basic principles of conservation as established in the Law?

A. The Law of Hydrocarbons and its Regulations contain various provisions that empower the Government to exercise all the necessary conservation measures. The Law grants the concessionaire exclusive rights of production of oil and gas found in the tract between the hypothetical vertical planes drawn through the concession boundaries. The "rule of capture" as known in the United States is not applicable in Venezuela.

The concessionaire, on the other hand, is obligated by the Law to produce oil and gas adhering to the technical principles applicable. In Venezuela, the presence of conservation principles is due more to the basic concept of state ownership of the oil reservoirs than to the influence of conservation policies, such as adopted in the United States. Basic legal provisions which govern conservation of oil and gas have a great flexibility, and their application to particular problems depends on the reservoir characteristics.

Q. Is the oil industry in Venezuela subject to governmental intervention?

A. The oil industry is under legal obligation to furnish the Government all the data which it may require in order to have a thorough knowledge of the development of the industry.

The Government has the right to inspect all the works and activities related to the exploration, production, refining, transportation and handling of petroleum, natural gas, asphalt, and other hydrocarbons, and to examine and verify the operations of the industry which are subject to taxation.

The outstanding feature today of the operation of the oil industry of Venezuela is the excellent relations existing between the Government and the oil companies. ★ ★ ★

*1 Bolivar = 30 cents.

API Board Tackles Big Job

No time for loafing at Directors' meetings . . . as present Chairman says . . . "If you get complacent in this business, you're dead"

By an Observer

AT THE 37th annual convention of American Petroleum Institute in Chicago members of the Board of Directors will meet on the third floor of the Conrad Hilton Hotel.

Have you ever thought what these hundred men — that's an average attendance — do at this assembly?

Participating in one or more of these sessions, or even sitting in as an observer, may seem to hold promise of excitement, intrigue, perhaps even adventure. To tell the truth, you'd probably be bored. The meetings are fairly routine in scope and nature. They are much the same as any business conference or committee session of the API. Look at last year's program and you can see what we mean.

Agendas, at first glance, seem fairly impressive, studded as they are with names of prominent leaders in petroleum. Reports they make are interesting but are presented with little fanfare. Sometimes the reports are discussed; more often they are received as is, and the group moves on quickly to the next item of business.

No Battle Ground

Unlike movie versions of supposedly high-powered board meetings — the celluloid kind which spark with drama, tension, and conflict — the API Board meetings are soft in tone and conventional in concept. As a rule, the atmosphere is relaxed, almost casual. Rare, indeed, is the day when a speaker's voice rises above anything but normal volume. Even rarer is the day when a voice reflects anger, challenge or any form of temperament.

This, in itself, is highly impressive — the amazing harmony and equanimity that exist at these sessions. When you remember the diverse backgrounds of the individuals in the room, the philosophical and geographical differences as well as the industrial concepts and the competitive forces that they represent, you know that the very calmness of the air is achievement.

Anyone familiar with petroleum industry people cannot help but be impressed by the facts and identities of the men who sit and participate in an API Board meeting.

They include the most prominent leaders. They may be from the largest corporations or a one-owner firm; many associations are represented. The Board is a composite reflection of the varied segments of petroleum's many and diverse operations.

What It Doesn't Do

To discuss the API Board and what it does, perhaps a good perspective can be obtained by spelling out some things it does not do.

1. It does not compete with other oil industry associations. It believes those most favorably situated should study and/or handle specific problems.
2. It does not tackle problems or activities that should be solved by the management of an individual company.
3. It does not enter into matters where its work might benefit some oil interests at the expense of others.
4. It does not test, recommend, or approve articles of any kind for use. It does not sponsor or hold exhibitions of equipment and supplies offered for sale to oil business managements.

These same four points guide and permeate all API activities and affairs. In effect, the Institute is non-denominational in its actions and ambitions, and strives mightily to remain so at all times.

Committees Do the Work

Now that we know some of the things that it doesn't do, then what does it do at a meeting? What goes on that takes up, in round figures, a day and a half of these gentlemen's time during every API annual meeting.

Like every organization, the Institute has a number of standing committees, which function the year 'round, doing things that would be cumbersome or impossible if they were to be handled by the full board.

Frank M. Porter became tenth president of API in 1950. He began in the oil business in Ardmore in 1916 and two years later became associated with Wirt Franklin, prominent independent early wildcatter. In 1939 he and the late Leslie Fain founded Fain-Porter Drilling Company, which Porter still owns and operates. A good industry statesman, he served many organizations before taking the API post.

Chairmen of standing committees make reports on their activities. These include such items as agriculture, safety, highways, national oil policy, United Nations activities, membership, nominations, medical and health, public relations, the 1959 Centennial, asphalt and so on.

On the first day, it is not unusual for as many as 20 of these reports to be made. That pretty well kills off the first day's agenda. Next come the reports of chairmen of general committees of the various divisions and

special projects — Marketing, Refining, Research, Transportation, Production, Finance and Accounting.

Program Set Up

By this time, most divisions, departments and others have filed orally or on paper their projected programs and expenditures for the next calendar year. These are referred automatically to the Program and Budget Review Committee. It convenes immediately afterward to study and coordinate spending plans, for further recommendation to the Executive Committee.

During the course of its day and a half of sessions, the Board manages to find time to listen to a report from the Board of Councillors which contains recommendations on Board elections. The Board appoints a committee to nominate the 21 members that it will elect. The Board elects officers for the next calendar year. It listens to any side speeches or discussions that any individual member or group of members desires to make.

Soap Box Is There

The Board is completely democratic on this latter score. Its philosophy is that if any member wants to talk about any pertinent subject, or bring any particular notion before his fellow members, he can do so by requesting permission to speak, and taking the floor. Members listen quietly, then swing on to the next item of business when the oration is completed.

Once in awhile there may be some controversy, and if there is, and the members feel that a problem is at hand which should be studied, a special committee is appointed to examine all of the aspects, and report back to some future meeting.

In the same vein, when a special committee makes a report, Board members know that it has been researched thoroughly, and that the report and recommendations, if any, are about the best that can be made. That's why the Board frequently will accept reports and recommendations from their colleagues without much ado, for they themselves have served on very similar study committees.

The agenda for this year's Board sessions will cover most of the standing committees, as enumerated above, and the usual divisional reports. There is nothing controversial on the agenda, yet the various items are of sufficient complexity that they will require Board hearing and Board approval.

In keeping with the character of the API by-laws, the Board must sanction API's activities and charter a course for its policies. The Board, of course, dictates all API policies.

The API Board has been meeting in PDR 1 and 2 in the Conrad Hilton as long as the annual sessions have been held in Chicago. Actually, the meetings are held in PDR 2, and PDR 1 provides an ante-room, where sidebar conferences, or other mutual discussions can be held without disturbing the general body.

Board members sit in regular hotel chairs arranged in theatrical style. At the front of the room is the table typical of a business meeting.

The usual occupants are the Chairman of the Board (in this case, Jake L. Hamon); the President of the Institute (Frank M. Porter); the Secretary of the Institute, who takes the minutes; and the president's chief aide, D. V. Stroop.

On the left side of the room, just a step or so away from the presiding officer's table, is a small rostrum, equipped with microphone and reading light. It is from this point that the various committee chairmen read or present their reports to the membership.

Who Belongs to Board

Now that we know all about the Board, how is its membership elected? And for how long?

The Board is composed of 151 members, as follows:

- 121 elected members;
- 19 honorary members;
- 8 ex-officio members, representing other trade associations;
- 3 ex-officio members, representing designated officers of the Institute itself.

Of the 121 elected members, 100 are chosen by the membership of the Institute at the general session. Because of the rotation system that has been established, however, only 50 members are up for election or re-election at any one meeting.

These 50 members are nominated by the Board of Councillors, which meets this year on Monday afternoon to do its work. (The Board of Councillors is appointed by the Board of Directors, and consists of members of the rank and file, representing each and every segment of the industry.) The remaining 21 Board members are elected by the Board itself, to give representation and balance where needed.

The eight ex-officio directors, in the trade association group, serve as members of the API Board during their terms in office as presidents of designated oil, or related, industry association groups.

Specifically, these associations are: American Association of Oilwell Drill-

SAMPLE AGENDA

Here's Work API Board of Directors Did at 1956 Annual Meeting.

First Morning

10:00 Approval of Minutes of Previous Meeting.
10:05 Deceased Board Member — S. B. Irelan.
10:10 Report of Treasurer — B. B. Jennings.
10:15 Interim Report — Program and Budget Review Committee — J. C. Donnell, II, chairman.
10:25 Membership Committee — W. K. Warren, chairman.
10:30 Agricultural Advisory Com. — W. W. Vandeveer.
10:40 Economic Processes Study Com. — S. A. Swensrud.
10:50 National Oil Policy Committee — A. Jacobsen.
11:00 Safety Committee of the Board — R. G. Follis.
11:10 Committee for United Nations Activities — B. B. Jennings, chairman.
11:20 Highway Coordinating Committee — L. S. Wescoat.
11:50 American Petroleum Industries Committee — Robert H. Scholl, chairman.
12:10 Announcement of 50 nominations as made by the Board of Councillors for election by API members.
12:15 Appointment of special committee to nominate 11 directors-at-large for election by Board.
12:20 Committee on Nomination — L. F. McCollum.

First Afternoon

2:00 Special Items — Frank M. Porter, president.
2:20 Committee on API Employee Benefits — M. J. Rathbone, chairman.
2:30 Medical and Health Committee — D. T. Staples.
2:40 Committee on Centennial Program — A. C. Long.
2:50 Public Relations Committee — H. S. M. Burns.
3:30 Special committee on nomination of 11 directors-at-large for election by the Board of Directors.
3:35 Asphalt Committee — Glenn E. Nielson, chairman.
3:45 Committee on Honorary Directors — J. N. Pew, Jr.
3:50 History Committee — Stanton K. Smith, chairman.
4:00 General Committee, Division of Finance and Accounting — P. C. Salman, chairman.

Second Afternoon

2:00 General Committee, Division of Refining — E. B. McConnell, chairman.
2:15 General Committee, Division of Marketing — J. G. Jordan, chairman.
2:30 Research Committee of the Board — Robert E. Wilson, chairman.
2:45 General Committee, Division of Transportation — Frank O. Prior, chairman.
3:00 General Committee, Division of Production — A. W. Thompson, chairman.
3:15 Budget of Expenditures for 1957.
3:20 New Business.

API Chairmen of the Board, Present and Past

Jake L. Hamon,
Dallas, Texas, Independent

P. C. Spencer,
President, Sinclair Oil Corporation

L. S. Wescoat,
Board Chairman, Pure Oil Company

W. Alton Jones,
Board Chairman, Cities Service Company, Inc.

ing Contractors; Atlantic Coast Oil Conference, Inc.; Pennsylvania Grade Crude Oil Association; Rocky Mountain Oil & Gas Association; Northwest Petroleum Association; National Petroleum Association; Natural Gasoline Association of America, Independent Petroleum Association of America.

Honorary Directors

As for the honorary directors, this is a category that was established in 1953. They are men who need no introduction to oil men anywhere; all are retired directors, men who have served as directors for at least a full decade, and who have rendered unusually distinctive service to the industry. Nominated by the standing membership, they are elected for life.

Two of the current group, J. Howard Pew, and Walter C. Teagle, are charter members of the original API Board organized March 27, 1919.

The original board consisted of 21 members, with the stipulation that it be restricted to 35 members in all. This organization meeting, coincidentally, also took place in Chicago, in the Blackstone Hotel, just across the street from the Conrad Hilton.

Board members are elected for two-year terms, and the rotation system has been established in such a way that only about one-half of the Board membership goes out of office annually. Members can be re-elected.

During the earlier years of its existence, the President of the Institute served also as Chairman of the Board of Directors, and presided at these and other API functions.

Board Chairman Post Created

Back in 1949, the Board amended the Institute by-laws to provide for a chairman, whose term of office would be for one year, with a maximum of two one-year terms. It is an honorary job with no compensation. But it does involve a fair work schedule and some sacrifice by busy oil men.

First formalized chairman of the Board was W. Alton Jones. An enthusiastic sportsman, rancher, farmer, and traveler, he invested substantial time and energy into his new assignment, the while, of course, maintaining and operating his own business affairs. Jones, incidentally, is the man who raised Cities Service to a company of national prestige, and whose own career went from a $45-a-week janitor to the head of this vast concern.

L. S. Wescoat took over the chairman's gavel in November 1951, following Jones. Wescoat, a native of Bridgeton, New Jersey, joined Pure Oil Company in 1925, started as general sales manager, and was promoted two years later to a vice presidency. In 1947, he became president of the firm, and subsequently moved up one notch higher to Chairman of the Board.

The man who succeeded Wescoat was Percy Craig Spencer of Sinclair. A man of wide interests, ranging from such as the National Petroleum Council to Chi Pi, Phi Beta Phi, and Sigma Delta Chi, he began his career as secretary to U. S. Senator Francis E. Warren, of Wyoming, in Washington, D.C., in 1919. In 1934, he joined Sinclair's legal department. Fifteen years later he was president of the firm.

Spencer was succeeded by Jake L. Hamon, the first "independent" in the slot. Hamon's second term comes to an end at this meeting. Who this will be is unknown until the Board convenes in Chicago, listens to the recommendations of its nominating committee, and formally votes a new man into the job.

Oilman Hamon has served as a hard-hitting spokesman for the industry, throughout some of its most troublesome times. His philosophy of direct action can best be summarized by his terse comment that "any time you get complacent in this business, you're dead."

Like predecessor Jones, Hamon started at the bottom, drilling his first well at 18. Also like other API Board chairmen, his biography catalogs a battery of distinguished groups to which he lent his name — and efforts.

Affairs of the American Petroleum Institute are in exceedingly capable hands — hands that from their own firms merit millions of dollars each year in compensation. Encouragingly, they find time to coordinate the affairs of the industry's biggest trade association, for the betterment of oil men everywhere, and the general public as well. ★ ★ ★

Where leakage cannot be tolerated...

Soils of resistivities under about 2,000 ohm-cm, or soils of widely varying resistivities averaging even 5,000 ohm-cm or more, are usually quite corrosive. For such soils Somastic® Pipe Coating is the ideal solution. To avoid the expense of frequent changes in pipe treating equipment and crews on long lines, Somastic Pipe Coating should be used in sections of perhaps five to ten miles minimum length through such soils, even though intermediate stretches were of higher resistivity.

Wherever pipe lines traverse city streets and subdivisions or valuable agricultural property, or lands that may soon be converted to such use, Somastic Pipe Coating is recommended. This added precaution is a good investment against the cost and public ill will that would result from a leak, even though soil studies may not indicate that severe corrosion should be anticipated. A further factor in such locations is that supplementary cathodic protection may not be feasible on poor coating because of the difficulty of obtaining suitable anode locations.

Somastic Pipe Coating has long been the standard for swamp construction, river and harbor crossings, and coated submarine lines. Experience indicates that submarine lines and river crossings can be installed when Somastic Pipe Coating is used without the expensive handling precautions normally required for other coatings. Examples of such use can be supplied including submarine lines in the Persian Gulf, in Lake Maracaibo and in the Pacific.

Although Somastic Pipe Coating can be damaged by unusually rough handling, it is true that it can be installed with a minimum of damage under conditions of mountainous terrain where prewrapped coatings would be damaged in handling and where over-the-trench machines cannot satisfactorily negotiate. Somastic Pipe Coating is usually the best choice when such construction problems are encountered.

Pipe lines are occasionally run through watersheds or river valleys where it is essential that every precaution be taken to prevent leaks. Such locations are an excellent application of Somastic Pipe Coating both because of the protection the coating affords and the evidence given to public authorities and others that the best possible pipe protection is being used.

you'll save money with SOMASTIC® coated pipe lines

SOMASTIC PIPE COATING is available in a number of formulations. Each is an asphalt-mastic designed for continuous, uniform, seamless, impermeable protection.

SOMASTIC PIPE COATING is *thick*. There are fewer pits under thick coatings. It is *seamless*. There are no holidays because of overlapping layers or bubbles. It is *reinforced*. The reinforcement is permanent and uniform. It is *rigid yet elastic* . . . withstands depression over long periods, absorbs pipe movement and changes in pipe line temperature. *Proved* under adverse soil conditions for more than 24 years. *That's why Somastic Pipe Coating will save you money wherever leakage cannot be tolerated!*

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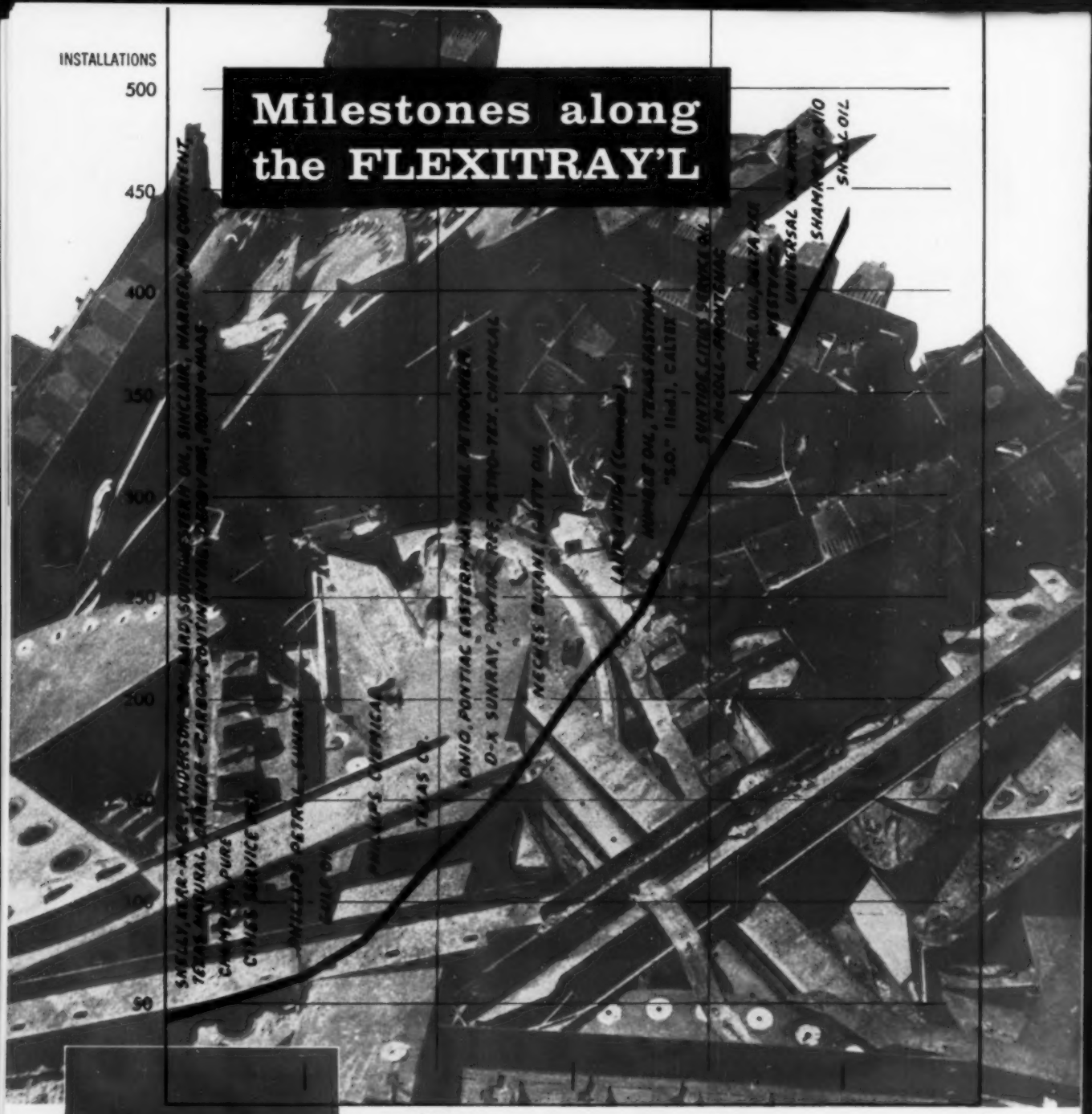
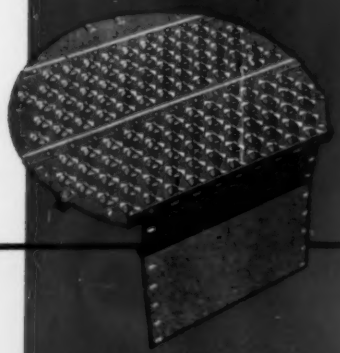
Milestones along the FLEXITRAY'L





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Now WYATT METAL & BOILER WORKS, with facilities for fabricating metal as thick as five inches, makes certain that the processing industries have the best that materials and workmanship of this day can provide.

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Wyatt's Plastics, Inc., now in its third year of matching the pattern of its parent company.

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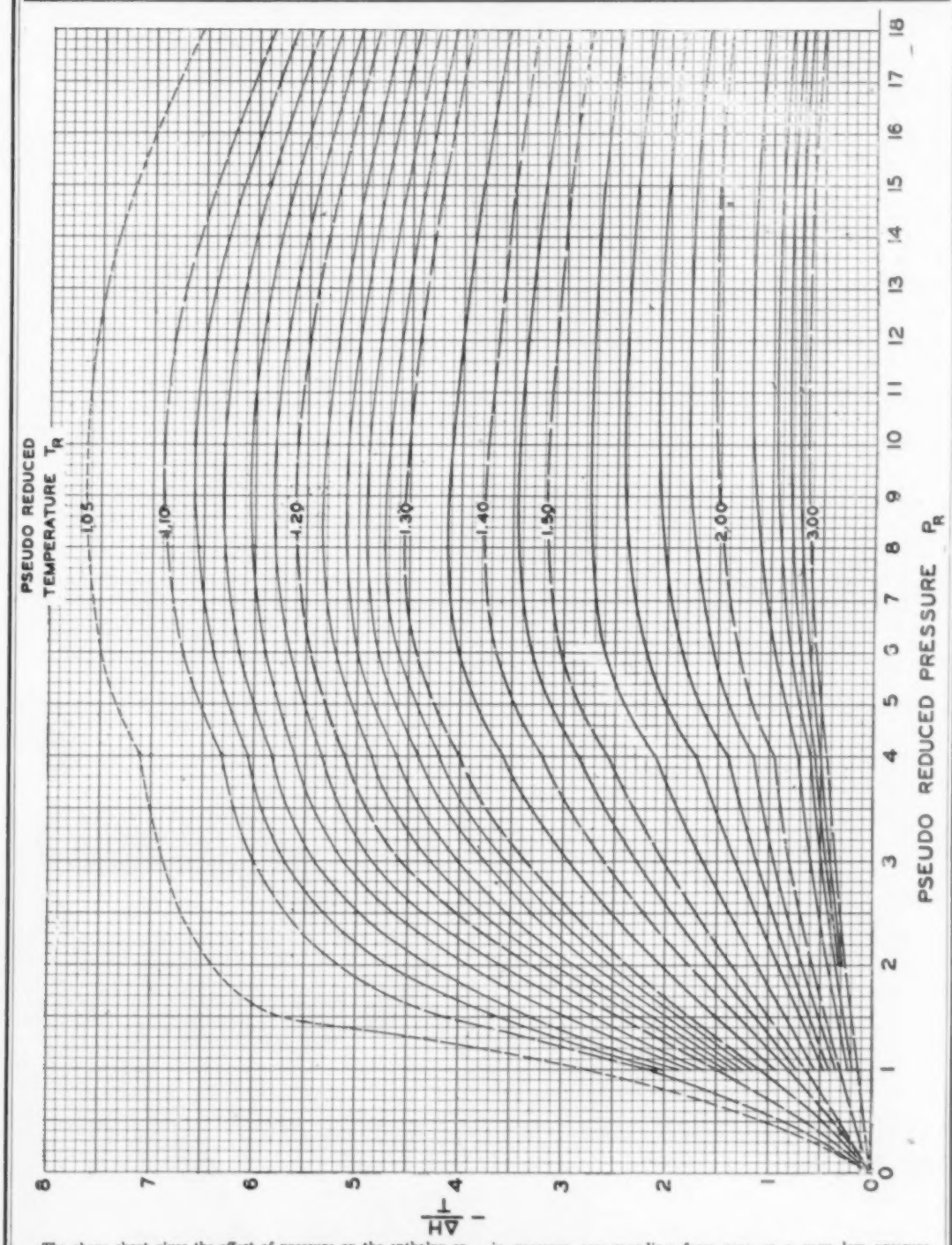
GRAVITY INDEX OF OIL

Viscosity of oil at 100 deg. fahr., Saybolt Universal seconds	Gravity of oil, °A. P. I.									
	18	20	22	24	26	28	30	32	34	36
100				33	56	73	87	98	108	114
125			3	39	61	78	91	102	111	117
150			12	44	65	82	94	104	113	119
175			17	48	68	84	96	106	114	
200			21	51	71	86	98	108	116	
225			25	54	73	88	99	109	117	
250			28	56	75	90	101	111	118	
275			31	58	76	91	102	112	119	
300			33	60	77	92	103	113	120	
350			37	63	80	94	105	114		
400		4	41	65	82	96	107	115		
500		12	46	69	85	98	109	117		
600		19	50	72	88	101	111	119		
700		23	54	74	90	103	113			
800		26	56	76	92	104	114			
900		29	58	78	94	105	115			
1000		32	60	80	95	107	116			
1250		38	64	84	98	109	118			
1500		42	68	87	101	112	120			
1750	5	46	71	89	103	113				
2000	10	49	73	90	104	114				
2250	15	51	75	92	105	116				
2500	18	53	76	94	106	117				
2750	21	55	77	95	108	118				
3000	24	57	79	96	109	118				

From McCluer and Fenske's chart, *Ind. Eng. Chem.* 24, 1371 (1932).

PRESSURE EFFECT ON ENTHALPY OF NATURAL GAS, CONSTANT TEMPERATURE

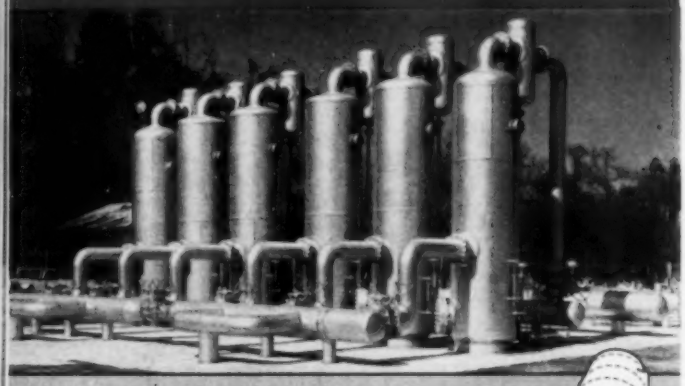


The above chart gives the effect of pressure on the enthalpy or heat content of a natural gas at constant temperature. The decrease in enthalpy may be obtained by multiplying the value on the ordinate (—H/T) by the absolute temperature for an increase in pressure corresponding from zero or a very low pressure where the vapor is substantially an ideal gas, to the pressure corresponding to the pseudo reduced pressure indicated along the abscissa.

—Chart by George Granger Brown, University of Michigan.

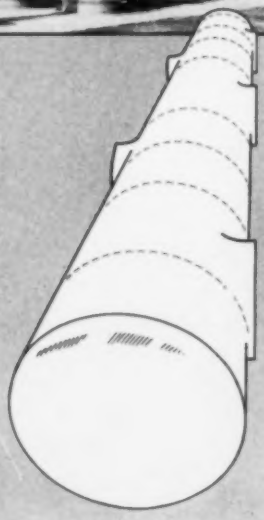
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

How Oklahoma Natural compounded savings by specifying cold extrusion



Oklahoma Natural Gas Company compounded installation savings at their South River Station, Tulsa, by (1) designing for multiple outlet headers and, (2) specifying Fluor-formed headers with cold extruded outlets.

The diagram at the right shows how each of the four 20″ O.D. headers at the South River Station eliminated five 20″ × 20″ × 12″ reducing outlet tees and eight 20″ welds (indicated by broken lines on diagram)—a total saving of 20 tees and 32 welds!



By specifying Fluor-formed headers with cold-extruded nozzle outlets, these added savings were realized

1. IMPROVED STRENGTH & DURABILITY – Polished extrusion dies impart a smooth, dense surface finish to the outlet—assurance of longer service life where vibration or pulsation stresses are involved.

2. CLOSER DIMENSIONAL TOLERANCES – Flowing steel under compression while in a tough stable condition permits extremely close tolerance dimensional configurations—center-to-center and centerline location tolerances are easily held within .060″.

3. LESS MATERIAL NEEDED – Fluor-formed cold extruded multiple outlet headers need no extra length for manufacture—they are made to the exact length and wall thickness required.

4. NO DELAYS – Because nozzle outlets are cold extruded, headers are often made from stock or from the same pipe used elsewhere in a job—production is faster, inspection is simpler.

DIFFICULT JOBS A SPECIALTY

Many difficult design problems can be solved by cold extrusion techniques. Qualified Fluor Products Company engineers are ready to furnish you specialized technical information on how this process can be utilized to save you time and money.

Contact: EXTRUSION SALES, Fluor Products Company, Paola, Kansas. WRITE FOR BULLETIN CE-0.001.

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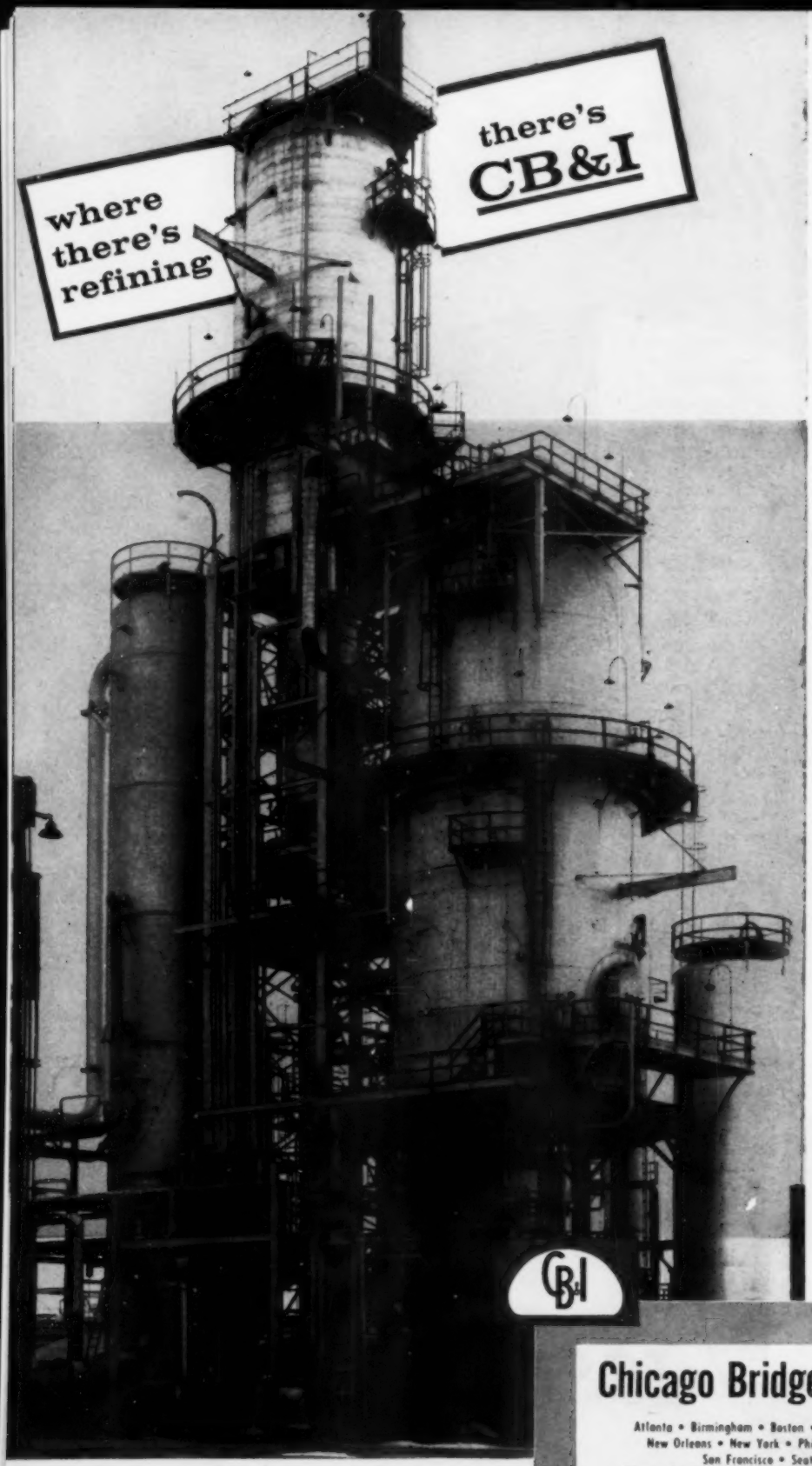

Above: UOP fluid catalytic cracking unit recently fabricated and erected by CB&I at the Detroit refinery of Aurora Gasoline Company.

ANOTHER UOP FLUID "CRACKER" FOR AURORA

This new UOP-type fluid catalytic cracking unit was fabricated in our Chicago plant and erected by CB&I at Aurora Gasoline Company's Detroit, Michigan refinery.

Its predecessor, recently dismantled at Detroit and re-erected by CB&I at Aurora's refinery in Muskegon, Michigan, was the *first* UOP Univessel-type fluid cat cracker.

Aurora Gasoline Company is an independent firm which has expanded constantly and with notable progress since their formation in 1932. In that time they have repeatedly taken advantage of the facilities for design, fabrication and erection of petroleum processing and storage structures offered by CB&I.

Whether *you're* building new or expanding, see CB&I *early* in your refinery planning. Write our nearest office for further information.

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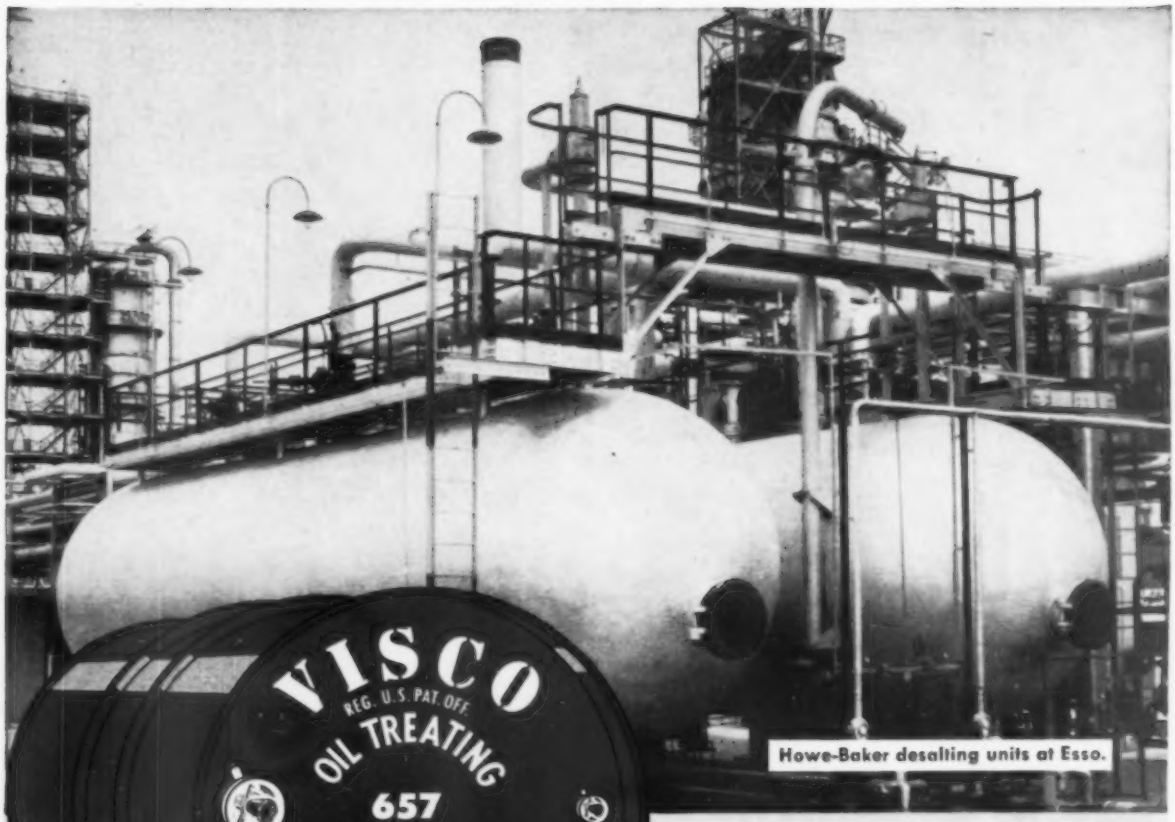

Howe-Baker desalting units at Esso.

desalting results

. . . a foregone conclusion at Esso's Bayway Refinery

The modern equipment shown above is one of the recent additions to the Esso Standard Oil Company Refinery at Linden, New Jersey.

With equipment such as this, plus the familiar blue barrels of Visco, outstanding desalting results are a foregone conclusion.

Visco, in either electrical or salt settling equipment, still provides the consistently efficient — and economical — chemical solution to the problem of greater throughput and lower corrosion costs.

Specific information on your particular desalting needs is readily available through your Visco Representative, or contact Visco direct.

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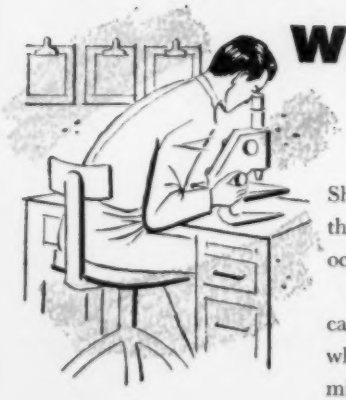
Layne Research Defends Your Well Water Supply



Shown here is an actual photograph of one of the many microscopic organisms which may occur in any type water supply.

Layne Research is called upon when well capacity is reduced. Layne Research finds out why. Production records, water analysis and microscopic examinations are some of the methods used to find the reason. Layne Research, thru years of experience in "recovering lost water," selects the correct Laynite material and method to restore well capacity.

IDENTIFY AND PRESCRIBE — that's what Layne Research does for each individual well water problem.

Only Layne Offers Complete Service: *Research* • *Analysis* • *Design* • *Wells* • *Pumps* • *Maintenance* • *Engineering*

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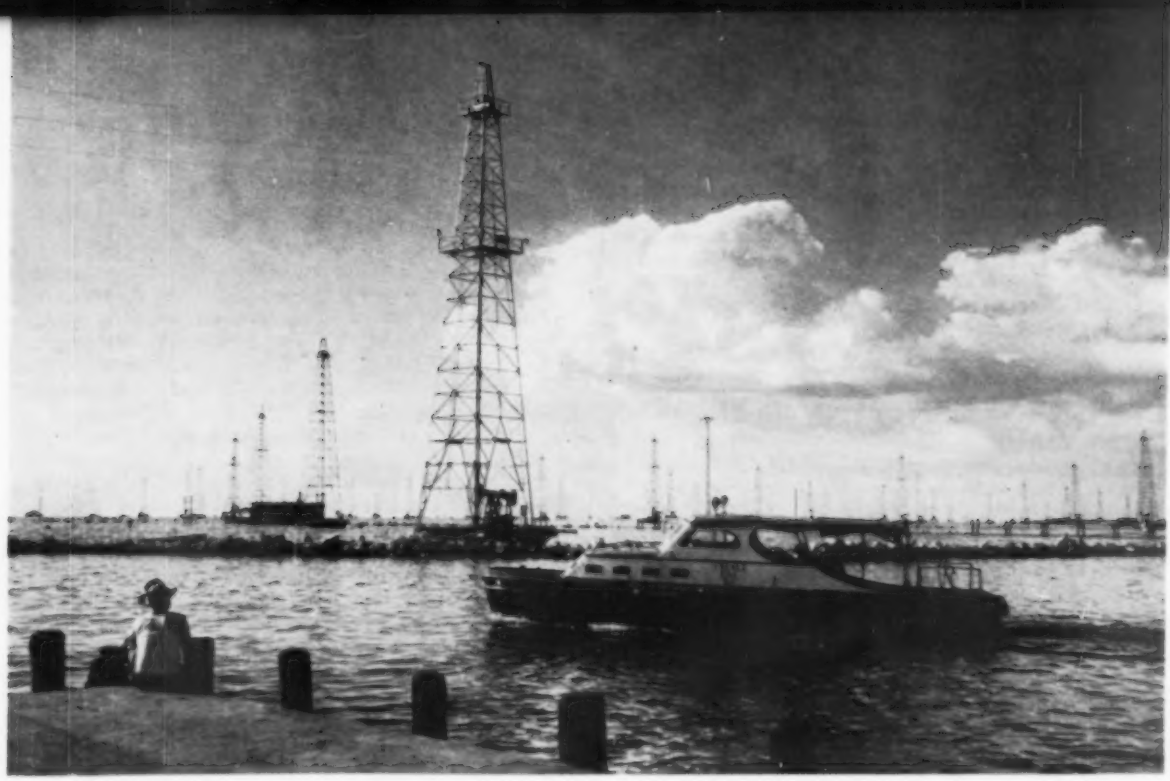


A partial view of wells on Lake Maracaibo, State of Zulia. There are now more than 3000 wells on the lake. — *Courtesy Creole Petroleum Corporation*

Educators Comment on Venezuelan Visit

Highlights from petroleum technology professors on a Creole-sponsored tour of operations

EIGHT college professors, specialists in petroleum refining, petroleum engineering and geology, visited Venezuela's fabulous oil fields in August. They were guests of Creole Petroleum Corporation, largest oil producer in Venezuela and one of the largest in the world.

The visit was part of the company's long range program to acquaint leading educators with progressive operational policies and methods now being used in oil production and refining in Venezuela. Guests also spent some time at two Venezuelan state universities.

About Venezuela, the visitors had these things to say:

'People Excellent Workers'

JAMES O. BALL
Head, Department of Petroleum Refining Engineering
Colorado School of Mines, Golden

"If I were 30 years younger, I would certainly be headed for this country for there is more activity here than any place I know and it appears that it will continue for a long time to come. Our visit included a trip through the refineries at Amuay and Carapito, through the oil fields in the Lake Maracaibo region and the fields at Maturin and El Tigre, as well as a flying trip over the iron mines.

"Except for very advanced or specialized training, there is little need now for a Venezuelan to go abroad for his education, whether he wants to become a doctor, a dentist, a lawyer, a school teacher, or an engineer — although many of them still do.

"There are exceptions, of course, especially in some branches of medicine and engineering, but for most career purposes a Venezuelan can get a good education through the university level right at home.

"The people of this country are very hospitable and are willing to help at every turn. They are excellent workers in every phase of industry."

'Venezuela's Progress Phenomenal'

CHARLES G. DODD
Halliburton Professor of Petroleum Engineering
University of Oklahoma, Norman

"Although I had expected to see large production facilities in Venezuela, I was amazed at the magnitude of operations relative to those of individual major companies in the States.

"Unique problems characterize many Venezuelan operations, especially those in Lake Maracaibo, and I appreciated the unique solutions such as use of tapered reinforced concrete piles up to 210 ft long and up to 4 ft sq in cross-section for locations in the lake, and the use of high-pressure centrifugal compressors at gas injection stations seven miles from shore.

"A large number of drilling and production problems in

Zulia are related to poorly consolidated, plastic formations that emphasize the need for a better understanding of rheological forces on a geological scale. By way of contrast, wells have been completed to 10,000 ft in six days in the State of Anzoátegui (northeast).

"Venezuela is progressing at a phenomenal rate with the help of oil royalties. Caracas is said to be the fastest growing city in the world. Malaria and yellow fever are wiped out in all inhabited areas. The climate is pleasant, except in the West at sea level."

'Universities Facilities Excellent'

W. B. BLEAKLEY
Associate Professor, Petroleum Production
University of Tulsa, Oklahoma

"Both Universidad Central de Caracas and University of Zulia in Maracaibo have vacated their locations and have moved to new buildings that have been constructed on vacant lands, or lands cleared by tearing down slum areas. The architecture in both cases is ultra-modern, not hampered by Old World tradition, and the building and grounds are spacious.

"Laboratory facilities are excellent, and the most modern equipment has been used throughout. At University of Zulia, the petroleum engineering building is nearing completion and will be one of the best physical plants in the world. On the other hand, practically all of the building hardware, plumbing and laboratory apparatus is 'Made in U. S. A.'

"In the field of petroleum engineering, University of Zulia is expecting a rapidly increasing enrollment which should do much to alleviate the apparent shortage of engineers, and satisfy the personnel requirements of companies operating in the area."

'Accent Is on Youth'

EDWARD V. O'ROURKE
Professor, Petroleum Engineering Division
Ohio State University, Columbus, Ohio

"Health conditions are good and the climate pleasant in Eastern Venezuela.

"In oil operations we found a high average production per day per well; Creole's average is 400 bbl per day per well. Pressure maintenance projects are already underway, and will be greatly expanded to increase petroleum recovery.

"Accent is on youth — Creole's chief petroleum engineer of the West is 30 years of age and chief petroleum engineer of the East is 32 years. Venezuela is a good place for career men in the oil business."

'King-Size Petroleum Industry'

V. BROWN MONNETT
Head of Geology Department
Oklahoma State University, Stillwater

"A casual visitor to the petroleum industry in Venezuela is immediately impressed by the 'king-size' of almost every facet of the industry from the surface storage of 8½ million bbl of fuel oil to the 230-ft concrete piles being made for use in Lake Maracaibo.

"A second vivid impression is the effort being made by both the participating companies and the Venezuelan government to educate and train an increasing number of Venezuelans in the many phases of the petroleum industry. The new Universities of Caracas and Zulia already have physical plants which would be envied by many state universities."

'Like United States Operations'

H. G. BOTSET
Head, Petroleum Engineering Department
University of Pittsburgh, Pennsylvania

"I was impressed by the magnitude and caliber of the production operations I saw in Venezuela. The equipment is as modern and as mechanized as that used in the United States. Except for the language, it was hard to realize that we were not visiting United States operations. The esprit de corps and enthusiasm of both the United States and Venezuela personnel was noticeable. The staff living facilities in company camps were well planned and of fine quality.

"At present civil engineering is the most generally taught field of engineering in Venezuela colleges. At University of Zulia the new petroleum engineering department seems to be very well equipped with laboratory and other facilities. Universidad Central in Caracas has a beautiful modern campus and, I understand, is about to establish a petroleum engineering department. It may be expected that these two universities will soon be turning out competent petroleum engineers for Venezuelan operations."

'Marine Operations Advanced'

W. L. DUCKER
Professor of Petroleum Engineering
Texas Technological College, Lubbock

"The remarkable thing about Venezuela is the pace and the scale of things. Generally, drilling and production methods are orthodox, but longer supply lines necessitate rather tremendous warehouse stocks of tubular, as well as all other goods.

"Marine operations have, of course, been developed to a high state of advancement on the lake, where even the gas injection plants have taken to the water. It is further anticipated that the bar at the mouth of the lake will be dredged down within the next year or so to provide the new supertankers access to the lake and to the loading docks serving the lake fields and the Bolivar coastal fields.

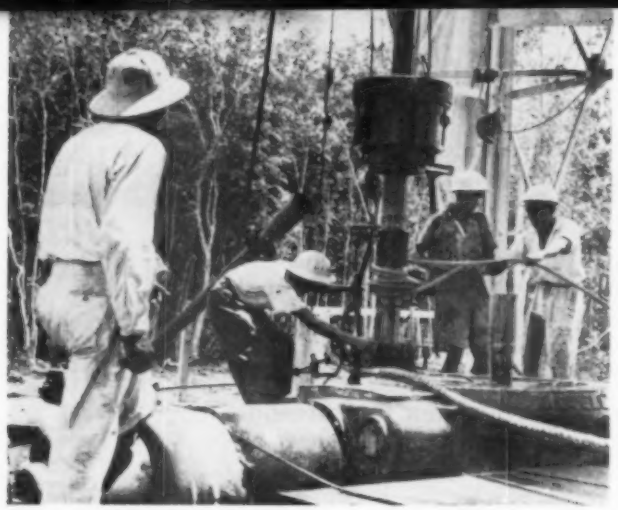
"Even more now than ever before Venezuela holds tremendous opportunity for the young engineer who has the will to take advantage of those opportunities, and what is more, in the Venezuela of today, he need no longer equip himself with a mosquito net and machete."

'Young, Energetic Country'

DR. CARL A. MOORE
School of Geological Engineering
University of Oklahoma

"One of the secrets of Creole's success lies in the on-the-job training programs. Every employee from management down is in constant training for a better position. This provides a continuing challenge to every employee to better himself in his company. In addition, Creole is engaged in training and teaching people about the petroleum industry in Venezuela, by continually sponsoring groups through their operations.

"Venezuela is a young, energetic country where most work is carried on by young people, either Venezuelan or North American. Technical advances are the most important of any area of the world, and there is a spirit of challenge to the geologists and engineers to find a bigger oil field, drill into a deeper producing horizon, drill a deeper well in deeper water of Lake Maracaibo, pump more oil using larger equipment. This entire process is permeated by the spirit of conquest and of research." ★ ★ ★



An oil strike in the jungle (left) leads to other developments — new villages, farms, rubber and copra gathering, etc. Right — more than 96 percent of STANVAC's employees are Indonesian.

Oil Company Pushes Back Jungle— People Follow

STANVAC has opened new areas for Indonesians in its $80 million development program in Sumatra . . . the new government and the company have cooperated for mutual benefit . . . reports National Planning Association

IN 1946 the Indonesian people were engaged in a revolution against the Dutch. The outcome was uncertain. STANVAC, a subsidiary of Standard Vacuum Oil Company, had to decide at that time whether the company should go back into Indonesia after the war. Before the war the company had, over a period of many years, built up some development on the island of Sumatra, but in 1942 all its facilities were destroyed or damaged by the Dutch in advance of Japanese invasion. The Japanese reconstructed the refinery and other installations, only to have them demolished a second time by Allied bombing.

Against the political confusion and the destruction of the property, the company had four facts in its favor:

1. It still held development rights on lands with proved crude oil reserves.
2. It had conducted surface explorations over other areas in which it hoped to obtain new exploration and development rights.
3. It had well-established markets east of Suez.
4. Its management group included persons with decades of accumulated experience in Indonesian operations.

Since that time STANVAC has spent some $70 to $80 million and both the company and the Republic of Indonesia, which is a nation in the making, have gained from the contract.

The National Planning Association has selected "STANVAC in Indonesia" as its case study No. 6 on United States business performance abroad.

First, the company is a large taxpayer and a substantial earner of foreign exchange. Petroleum and petroleum products account for nearly a quarter of the total export value and the industry provides some 10 percent of Indonesia's total tax receipts. Oil operations open new frontiers which the local population can use for productive purposes. After the exploration parties have cut trails through tangled jungle, the people follow them into the new area. When oil is found and development begins then access roads, pipelines, stocking facilities, and later homes, schools and hospitals must be built. These become available to the general public and reduce the load on government budget. STANVAC contracts for a wide variety of operations afford opportunities for contractors to learn new businesses and to use improved methods. Contracts are given for cleaning and maintaining pipeline rights of way, for handling derricks and tanks, for carpentry, motor vehicle repair and operation, etc.

On-the-job training is conducted at all company installations and specialized training is provided for supervisors. Skilled employees are sometimes sent to Indonesian institutions or abroad for special training at STANVAC's expense. Because of the expansion of the company, the number of trained Indonesians have never caught up with the demand.

Part of the company's training program is a four-year nursing course. The company maintains 12 clinics and three hospitals in Sumatra and keeps a medical check on its employees. In all, its health and hospital facilities care for about 60,000 persons.

The operations are unionized and a system of collective bargaining has evolved much like the United States pattern. States the NPA report, "The company appears to have done extraordinarily well in its relations with its employees . . . its labor troubles have not been severe . . . and the record compares favorably with that of other foreign employers in Indonesia."

There are housing developments, many fringe benefits. Family earnings of oil workers are more than double the average income per family for the whole of Indonesia. Overtime is paid in excess of 40 hours a week.

The study concludes that STANVAC has been successful both as a business enterprise and as a factor in Indonesian social and economic development. It has opened up new frontiers, introduced new techniques and ideas, contributed to the country's own development program through its taxes and foreign exchange earnings. ★ ★

Who Got New Concessions and What They Cost

When Venezuelan government opened new lands to oil operations, eight firms — some made up of a group of companies — received their first acreage

Neal R. VanMiddlesworth

IN 1956, and again in 1957, the Venezuelan government announced that it would accept bids on new oil concessions.

Areas involved were five: Lake Maracaibo, the Gulf of Paria, Barinas, North Monagas, and South Monagas. In addition, successful bidders were obliged to take highly speculative acreage along the Colombian border in amounts roughly proportionate to the other acreage awarded them.

It had been 10 years since the last concession awards had been made in Venezuela. In the meantime, world demand for oil had surpassed all expectations. As a result, the response to the Government's invitation was overwhelming. In 1956, oil rights worth $315,000,000 were awarded; the 1957 grants brought another $370,000,000 into the national treasury.

Five concessionaires already established in Venezuela took a big slice of the new awards. Eight other U. S. companies, or groups of companies, became concessionaires in Venezuela for the first time. These ranged from big integrated companies with other foreign holdings to smaller operators seeking oil abroad for the first time.

One operator said that cost of concessions inspired group buying. His company, he stated, was one of the big ones in the United States, but its management wanted to share the costs in Venezuela.

Continental operates in the Gulf of Paria for a group with these interests: Conoco 25 percent; Texaco 25 percent; Ohio Oil 25 percent, Cities Service 16⅔ and Richfield Oil 8⅓.

Four tracts operated by Phillips are owned by: Phillips 55.75 percent; Sunray Mid-Continent 17.27 percent; Ashland 10.79 percent; Western Natural Gas Co. and El Paso Natural Gas 6.47 percent; Kerr-McGee 5.40 percent, Pacific Petroleums and Canadian Atlantic 4.32 percent. Another two concessions are owned by: Phillips 45 percent; San Jacinto and Associates 25 percent; El Paso Natural Gas Products 10 percent, Western Natural Gas Company 10 percent; Sunray Mid-Continent 5, and Pacific Petroleums, Ltd. 5.

In other words the title holder may represent a number of owners and may not be the operator. Newcomers include Murmac Oil (Clint Murchison), Seaboard, Superior, Signal, Pure, Amerada, Lion, Murphy, Union Oil and Gas, Hancock, Sohio, Star Oil (Joseph Davidson, Washington, D. C.), etc.

The Author

Neal VanMiddlesworth *is founder and operator of the Venezuelan Oil Scouting Agency (VOSA), Apartado 3963, Caracas. VOSA publishes periodical industry-wide reports, covering all phases of Venezuelan oil operations, for clients in Venezuela, the U. S. and Europe.*

Mr. VanMiddlesworth was Mene Grande Oil Company's chief scout for 10 years before establishing his own service.

TABLE 1. 1956-57 VENEZUELAN CONCESSION AWARDS.

By types, zones, years.

ZONE	YEAR	HECTARES	BOLIVARES	AVG. BS/HEC	ACRES	DOLLARS	AVG. $/ACRE
I. EXPLOITATION ACREAGE (for immediate development; 100% retained)							
Lake Maracaibo	1956	111,713.65	Bs 945,721,131	8,465	276,044	$ 306,058,618	$ 1,109
" "	1957	30,000.00	351,000,000	11,700	74,130	113,592,233	1,532
Gulf of Paria	"	88,307.00	385,923,492	4,370	218,207	124,894,334	572
South Monagas	"	69,650.00	195,314,153	2,804	172,105	63,208,464	367
Barinas	"	11,276.86	67,786,047	6,011	27,865	21,937,232	787
		310,947.51	1,945,744,923	6,257	768,351	629,690,881	820
II. EXPLORATION ACREAGE, NON-BORDER (Exploration period up to 3 years; 50% retained)							
Barinas	1957	121,540.00	70,370,000	579	300,325	22,773,463	76
N Monagas	"	29,320.00	47,058,600	1,605	72,450	15,229,320	210
		150,860.00	117,428,600	778	372,775	38,002,783	102
III. EXPLORATION ACREAGE, BORDER (obligatory; in Apure, Tachira, and Zulia)							
	1956	199,550.00	30,171,250	151	493,088	9,764,159	20
	1957	159,940.00	23,991,000	150	395,212	7,764,077	20
		359,490.00	54,162,250	151	888,300	17,528,236	20
GRAND TOTALS		**821,297.51**	**Bs 2,117,335,673**	**2,578**	**2,029,426**	**$685,221,900**	**$338**

Details of the $685,000,000 operation — perhaps the biggest of its kind ever made anywhere in so short a time — are given in the two accompanying tables.

The underlying significance of this series of transactions is vastly more important that the staggering sums of money involved in these initial payments, and will result in the nation's receiving many times the original $685,000,000. As long as new concessions were withheld, the oil industry in Venezuela had only a limited lease on life. When the existing fields were drilled up, as had already taken place in a number of areas, the industry faced a period of slow but certain decline and finally extinction.

New concessions, by providing new areas to be explored and, inevitably, new fields to be found, open new horizons and new possibilities of achievement to the Venezuelan oil industry. ★

TABLE 2. 1956-57 VENEZUELAN CONCESSION AWARDS.

Summary by Concessionaires.

TITLEHOLDER	TYPE	ZONE	YEAR	HECTARES	BOLIVARES	ACRES	DOLLARS
MENE GRANDE	Exploit.	Lake	1956	51,333.56	Bs 415,517,608	126,845	$134,471,718
(Gulf)	Oblig.	Border	"	40,000.00	6,000,000	98,840	1,941,747
				91,333.56	421,517,608	225.685	136,413,365
CONTINENTAL	Exploit.	Paria	1957	61,515.00	314,060,490	152,004	101 637,699
	Oblig.	Border	"	40,000.00	6,000.000	98,840	1,941,747
				101,515.00	320,060,490	250,844	103,579,446
SHELL	Exploit.	Lake	1956	24,122.59	206,895,030	59,607	66,956,320
	"	Paria	1957	10,000.00	36,350,000	24,710	11,763,754
	Oblig.	Border	1956	40,000.00	6,000,000	98,840	1,941,748
				74,122.59	249,245,030	183,157	80,661,822
CREOLE	Exploit.	Lake	1956	10,296.93	77,248,094	25,444	24,999,383
	"	S. Monagas	1957	31,296.00	60,755,458	77,332	19,661,961
	Explor.	Barinas	"	80,000.00	46,600,000	197,680	15,080,906
	"	N. Monagas	"	29,320.00	47,058,600	72,450	15,229,320
	Oblig.	Border	1956	40,000.00	6,000,000	98,840	1,941,748
				190,912.93	237,662,152	471,746	76,913,318
SAN JACINTO	Exploit.	Lake	1956	797.00	11,970,000	1,969	3,873,787
	"	Lake	1957	10,000.00	150,000,000	24,710	48,543,689
	Oblig	Border	1956	10,000.00	1,500,000	24,710	485,437
	"	"	1957	10,000.00	1,500,000	24,710	485,437
				30,797.00	164,970,000	76,099	53,388,350
VENEZUELAN SUN	Exploit.	Lake	1956	10,000.00	56,000.000	24,710	18,122,977
	"	"	1957	10,000.00	101,000,000	24,710	32,686,084
	Oblig.	Border	1956	10,000.00	1,500,000	24,710	485,437
	"	"	1957	10,000.00	1,500,000	24,710	485,437
				40,000.00	160,000,000	98,840	51,779,935
PHILLIPS	Exploit.	Lake	1957	10,000.00	100,000,000	24,710	32,362,460
	"	S. Monagas	"	10,000.00	35,110,000	24,710	11,362,460
	Oblig.	Border	"	20,000.00	3,000,000	49,420	970,873
				40,000.00	138,110,000	98,840	44,695,793
PAN VENEZUELAN	Exploit.	Paria	1957	9,010.00	14,416,000	22,264	4,665,372
(Stanolind)	"	S Monagas	"	28,354.00	99,448,695	70,063	32,184,043
	Oblig.	Border	"	40,000.00	6,000,000	98,840	1,941,748
				77,364.00	119,864,695	191,167	38,791,163
SIGNAL	Exploit.	Lake	1956	11,175.34	104,070,912	27,614	33,679,906
	Oblig.	Border	"	40,000.00	6,000,000	98,840	1,941,748
				51,175.34	110,070,912	126,454	35,621,654
VENEZUELAN ATLANTIC	Exploit.	Barinas	1957	11,276.86	67,786,047	27,865	21,937,232
	"	Paria	"	7,782.00	21,097,002	19,229	6,827,509
	Explor.	Barinas	"	21,540.00	10,770,000	53,225	3,485,437
	Oblig.	Border	"	30,000.00	4,500,000	74,130	1,456,310
				70,598.86	104,153,049	147,449	33,706,488
SUPERIOR	Exploit.	Lake	1956	3,146.81	68,041,287	7,776	22,019,834
	Oblig.	Border	"	10,000.00	1,500,000	24,710	485,437
				13,146.81	69,541,287	32,486	22,505,271
KING-MILL	Explor.	Barinas	1957	20,000.00	13,000,000	49,420	4,207,120
	Oblig.	Border	"	9,940.00	1,491,000	24.562	482,524
				29,940.00	14,491,000	73.982	4,689,644
VAIOPA	Exploit.	Lake	1956	841.42	5,978,200	2,079	1,934,692
(operated by Sun)	Oblig.	Border	"	9,550.00	1,671,250	23.598	540,858
				10,391.42	7,649,450	25,677	2,475,550
TOTALS	Exploitation			310,947.51	1,945,744,823	768,351	629,690,881
	Exploration			150,860.00	117,428,600	372,775	38,002,783
	Obligatory			359,490.00	54,162,250	888,300	17,528,236
GRAND TOTALS				**821,297.51**	**Bs 2,117,335,673**	**2,029,426**	**$685,221,900**

The "meat" of even the best meals was often the table-talk.

Informality, yes. But with no lag in interest.

Advance Management Course in Caracas

Central University sponsors three-week programs for top executives with help of Northwestern University staff . . . Creole initiated plan . . . 236 persons have participated in seven courses

RAPID expansion of Venezuelan economy increases both opportunities and responsibilities of the management of companies who participate in it. As in all countries of the world there is a growing realization that management is not a phenomenon but a result of training.

To bring this training to Venezuela, Creole Petroleum Corporation enlisted the help of an experienced Northwestern University staff to design and conduct a management course. Not only Creole's own top management, but also other executives were invited to the six sessions held in 1957.

The program interested Universidad Central de Venezuela in Caracas, which decided to establish a management course on a permanent basis with the aid of Northwestern University. The plan now is that Northwestern will provide professors to conduct the program in English during the academic year of 1957-1958. At the same time several Venezuelan professors are taking specialized courses at Northwestern to prepare them to conduct the Programa Avanzado de Gerencia (Advanced Management Program) in Spanish in 1958-1959.

The program will be of interest to management in any company and, doubtless, is among the first developed in a university outside of the United States.

When under direct Creole sponsorship, 236 persons participated in the seven courses of 21 days each. One per month was given from December 1956, through June 1957. Of these "students," 35 were members of other industries, of various Venezuelan government dependencies and of the Central University staff, with a few from Latin American affiliates of Jersey Standard.

This year the program will be carried on for a 21-day period at Central University. Enrollment fee will be 3000 bolivars ($900), which provides all texts, study materials, board, room and services appropriate to such a program.

What Program Covers

The course is designed to strengthen the insights and mental skills of recognized leaders. Careful selection by companies is asked so that each participant will bring special knowledge to contribute to his group for mutual exchange of ideas.

Emphasis is on the case method of learning, which pools the best thinking of the group.

Desirable results of the course are that each man:

1 . . . develop awareness of "areas of ignorance";
2 . . . grasp relationships between scattered blocks of knowledge;
3 . . . see that the "why's" outrank the "what's"—that *reasons* outrank *mere facts;*
4 . . . recognize the importance of "seeing" possibilities where they are not expected;
5 . . . develop the techniques of *consciously* evaluating relevent alternatives;
6 . . . distinguish between facts, opinions, assumptions;
7 . . . see the danger of *assuming* understanding;
8 . . . discover respect for others' thinking;
9 . . . reveal hidden strengths of knowledge and insight within each man's self;
10 . . . acquire a hunger for further knowledge and development.

	Management Practices	Personal Relationship	Social Responsibilities
1st Week: Size Up and Analysis	The Conceptual Framework for Corporate Objectives	Recognition of The Individual	Corporate Goals in a Complex Social Environment
2nd Week: Determination of Objectives	Focus of Skills and Resources of the Corporation on Competitive Scene	The Individual and The Group	Corporate Citizenship and Social Philosophy
3rd Week: Organization and Controls	Integration of Functional Skills for Executive Action	Conflicts of Ideologies and Corporate Purposes	Ethics Corporate and Personal

Structure of Program

Each participant in the advanced management program is provided with a variety of specialized experience from which he gains an overall point of view. Executives absorb a great deal of information that helps them to analyze, plan, implement, and control a company's varied specialized departments.

The point is that a system of reasoning can be learned. In order to do this the course is divided into three major spheres of management thinking:

1 . . . *sizing up situations* by breaking problems down into component parts for analysis, and restructuring them into a concept adequate to determine corporate objectives;

2 . . . *determining company objectives* . . . bringing to a focus those human skills and materials and financial resources of the corporation to attack practicable goals;

3 . . . *organizing* for action to achieve determined objectives, and *establishing* controls to assure integrated performance of desired executive action.

Subject areas in these three divisions cover:

1 . . . *management practices* . . . interrelating special functions of marketing, finance, production, accounting, etc., into a framework that requires viewing departmental activities as a single endeavor designed to attain common corporate objectives;

2 . . . *personal relationships* . . . dealing with interpersonal and intergroup relationships within an organization designed to achieve defined purposes;

3 . . . *social responsibilities* . . . dealing with sociological issues inherent in the cultural environment of which men must adapt themselves, and ethical problems of corporate and personal citizenship.

Literature for Course

1. **The 20th Century Capitalist Revolution,** by Adolf A. Berle, Jr.; Harcourt, Brace & Company, New York, 1954.
2. **How to Talk With People,** by Irving J. Lee; Harper and Bros., New York, 1952.
3. **The Social Psychology of Industry,** by J. A. C. Brown; A Pelican Book.
4. **The Worldly Philosophers,** by Robert L. Heilbroner; Simon & Schuster, New York, 1953.
5. **Business Practices, Trade Position, and Competition,** by Oswald Knauth; Columbia University Press, New York, 1956.
6. **Administrative Action,** by William H. Newman; Prentice-Hall, Inc., New York, 1951.
7. **Time Out for Mental Digestion,** by Robert Rawls; Executive Development Text No. 1, The Updigraff Press, Ltd., Scarsdale, New York.
8. **How to Read a Financial Statement,** put out by Merrill Lynch, Pierce, Fenner & Beane.
9. **The Federal Reserve System — Its Purposes and Function,** put out by The Federal Reserve System.
10. **U. S. Business Performance Abroad — Creole Petroleum Corporation;** N. P. A.
11. **Customs and Crises in Communication,** by Irving J. Lee; Harper & Bros., New York, 1954.
12. **American Diplomacy, 1900-1950,** by George F. Kennan; University of Chicago Press, 1951.
13. **Building a Democratic Work Group,** by Leland P. Bradford and Ronald Lippitt; reprint from *Personnel,* Vol. 22, No. 3, A. M. A.
14. **The New Venezuela,** by Earl Newson; The Venezuelan Chamber of Commerce of the U. S., Inc., New York, 1956.
15. **Creole Petroleum Corporation Annual Report.**
16. **Standard Oil of New Jersey Annual Report.**
17. **The Federal Budget in Brief,** Fiscal Year 1956; Executive Office of the President, Bureau of the Budget, Washington, D. C.
18. **Leadership Pattern in the Plant,** by Chris Argyris; Reprint from Harvard Business Review, January-February 1954.
19. **Factors Influencing Employee Morale,** by James C. Worthy; Reprint from Harvard Business Review, January 1950.
20. **The Fateful Process of Mr. A. Talking to Mr. B,** by Wendell Johnson; Reprint from Harvard Business Review, January-February 1953.
21. **Barriers and Gateways to Communication,** by Carl R. Rogers and F. J. Roethlisberger; Reprint Harvard Business Review, July-August 1952.
22. **How to Make a Business Decision;** Reprint from Nation's Business, April 1956.

"Digging" was done individually, afternoons and late at night.

Attention given the course by board members was evident in the visit of Director Leo E. Lowry, standing at the extreme right.

Materials Used

"Case" materials are selected from actual incidents to show the need for improved communications, greater understanding, and appreciation of fellow workers.

Members will receive articles from management publications and a few carefully selected books (see box) from which assignments will be made.

A library in the field of business and economics, psychology and sociology is provided.

Outside speakers are invited for luncheon and for dinner to elaborate on certain special subjects.

Each day's program and each night's homework are carefully planned. Some 50 to 80 pages of reading matter are assigned each night. Executives study critically these assignments to use them as a springboard for discussion.

This advanced management program, initiated by Creole, is a big step in fostering advancement of management in Venezuela. It opens up a new field of more scientific management in a nation whose culture and economy is developing and expanding at a startling rate. ★ ★ ★

There are more

People in Petroleum

WHETHER they buy oil and gas company stocks or work in the industry, there are more people in petroleum than ever before.

In spite of automation, there were six percent more employees in 1956 for 50 petroleum companies than there were in 1955.

Pay and benefits increased faster than employment. They were up 10 percent over the previous year.

People are investing more extensively in petroleum companies. Last year the number of stockholders rose 12 percent above 1955. There are, doubtless, many duplications but the figure of almost two million stockholders of 50 companies is impressive.

Seven companies listed have more than 100,000 owners of common stock.

Last year Jersey Standard moved to third place in the nation for number of stockholders. American Telephone and Telegraph is first with about 1,500,000 owners. General Motors has 640,000 and Jersey 403,000.

One reason for increase in stock owners is company plans for employees to buy shares, sometimes at lower cost, sometimes by small monthly payments.

Esso Standard (Jersey affiliate) reported 20,000 employee stockholders, or three out of every four persons who work for the company.

The employee-stockholders may provide one reason for the increase in attendance at stock owners annual meetings. This annual accounting by management has become an important and much more interesting attraction for the capitalists of U. S. business. Better published annual reports have contributed to the interest.

The increase in employees refutes the often expressed anxieties of union spokesmen that employment rolls are cut by the growing use of instrumentation and automation equipment. A rise of six percent is large for any industry.

Increased employment has accompanied expanded automation. One reason involves expanded knowledge and new problems. As one research director puts it, "Every problem we solve raises three or four new problems." Another reason is the heavy capital expansion of the petroleum industry. Although automation is used economically in many operations, plants and activities are so extensive that employment needs continue to go up. ★ ★ ★

In one year

50 companies have

6% more employees

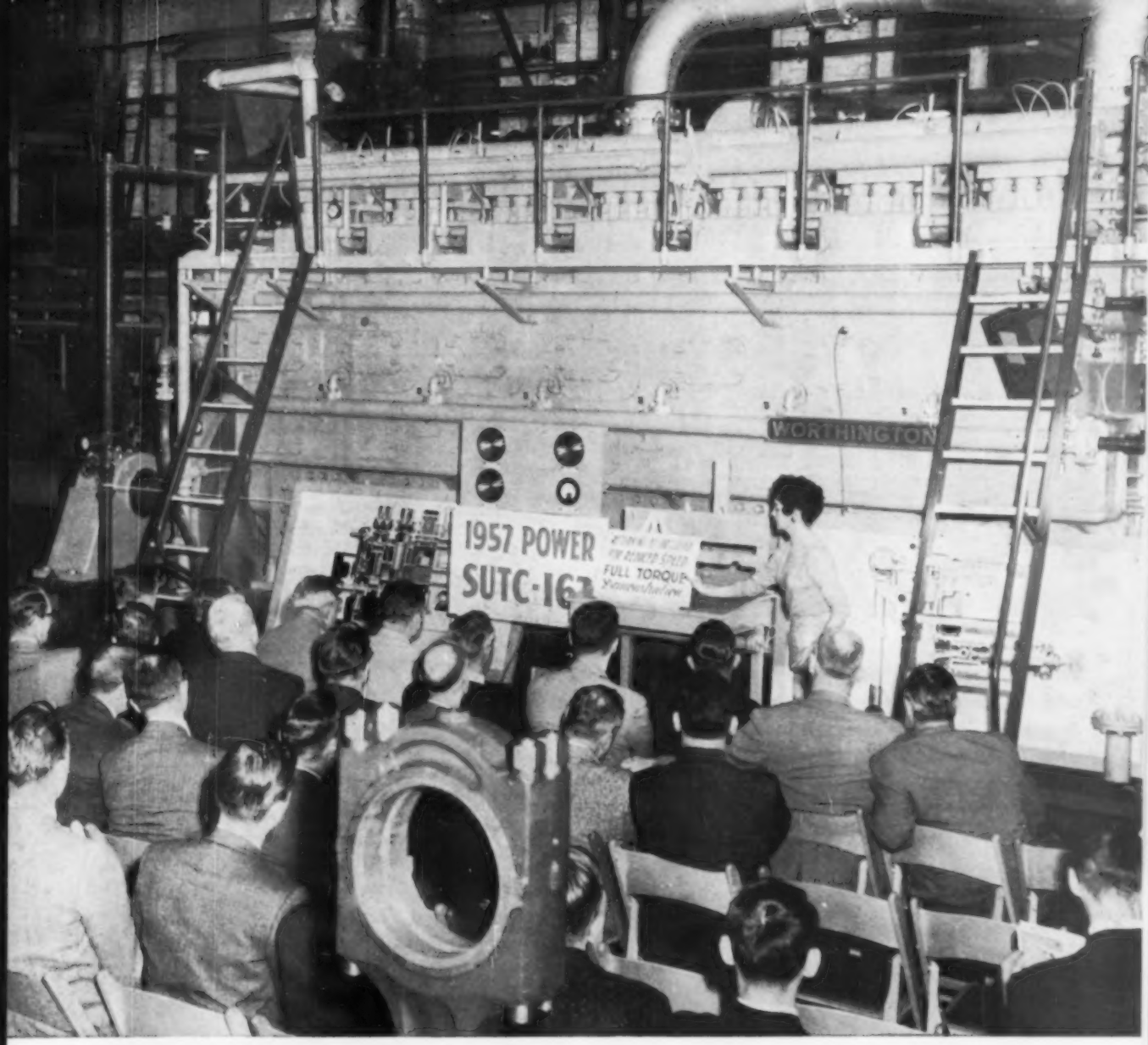
10% higher pay and benefits

12% more shareholders

PEOPLE IN PETROLEUM

Company	Holders of common stock		Employees		Payrolls & benefits ($1000)	
	1955	1956	1955	1956	1955	1956
Anderson-Prichard	4,500	5,250	880	931	5,137	5,848
Ashland O & R	31,172	34,303	4,300	4,600	—	—
Atlantic Refining	48,909	53,167	16,511	16,564	98,819	106,211*
British American	26,939	31,939	5,765	7,397	28,242	35,150
Clark Oil & Refining	1,249	3,588	1,400	1,800	4,161	6,422
Colorado O & G	7,033	8,758	NA	NA	2,805	3,515
Continental	29,283	29,504	9,366	9,837	58,800	64,400
Cosden Petroleum	3,769	6,500‡	678	732	3,952	4,923§
Fifteen Oil Co.	936*	1,278	30	37	221	276
General American	2,165	2,872	609	624	2,569	3,101
General Crude	1,076	1,102	225	220	1,442	1,450
Gulf Oil	73,705	85,225	47,200**	57,700**	230,850#	265,494#
Honolulu	4,174	4,489	594	631	3,951	4,765
Humble	8,340	8,900‡	18,729	19,001	115,848	127,445
Kerr County Land Co.	13,100	15,700	615	623	—	—
Kerr-McGee	2,935	2,460	1,325	2,000	7,357	11,412
Louisiana Ld. & Exp.	7,623	8,603	86	100	640	819
Macmillian Petroleum	1,713	1,852	280	303	1,529	1,741
Midwest Oil	7,597	7,633	88	99	NA	NA
Monterey Oil	3,150	4,071	385	394	2,675	2,824
Nortex O & G	367	378	25	81	102	335
Ohio Oil	37,134	41,108	6,616	6,637	38,004	41,800
Phillips Petroleum	90,246	102,906	25,208	27,461	155,329	177,560
Plymouth Oil	7,440	7,954	1,177	1,107	—	—
Pure Oil	35,041	40,456	12,869	12,102	65,785*	68,832*
Quaker State	—	6,047	—	1,586	—	—
Richfield Oil	12,000	12,000	5,666	5,914	33,939	37,272
Shamrock O & G	5,942	5,602	854	923	4,886	5,363
Shell Oil	19,025	19,727	38,845	39,903	265,223	293,657
Signal O & G	3,156	3,856	1,161	1,229	6,740	7,310
Sinclair Oil	107,163	114,806	24,657	25,125	139,530	153,664
Skelly Oil	5,642	5,965	4,875	4,750	24,929	27,255
Socony-Mobil	174,300	181,605	43,900†	44,500†	301,100†	317,800†
So. Penn Oil	9,921	10,201	2,428	2,397	10,133	11,083
Standard Calif.	119,793	137,381	36,369	38,854	224,331	250,071
Standard Ind.	132,800	143,200	51,520	52,010	330,800	358,600
Standard N. J.	324,000	403,000	153,000	156,000	838,700	905,600
Standard Ohio	35,151	36,972	11,279	11,514	65,198	73,633
Sun Oil	20,778	22,417	20,543	21,498	118,590	132,880
Sunray Mid-Con	95,953	97,634	5,770	5,955	30,396	34,863
Superior Oil	1,305	1,589	2,981	3,123	NA	NA
Texas Company	120,376	131,034	42,462	52,587	245,674	272,821
Texas Gulf	6,934	7,700	215	216	1,518	1,612
Texas Pacific	5,291	5,705	448	458	NA	NA
Tidewater	17,019	18,252	8,642	9,181	50,160	54,028
TXL Corp.	7,200	7,450	▶ 38	▶ 47	—	—
Union of Calif.	46,175	49,719	8,839	8,823	59,221	64,000
Union O & G of La.	1,389	1,450	394	393	2,838	2,574
Universal Consolidated	2,600	2,500	101	100	678	690
White Eagle	2,500	2,700	521	449	3,230	3,649
Wilcox	1,723	1,713	215	134	1,104	1,051
Woodley	1,416	1,564	76	80	498	537
TOTAL	1,735,148	1,941,785	620,760	650,730	3,587,624	3,944,336

NA — Not Available
*Exclusive of benefits.
†U. S. only.
‡Approximately
§Estimated
▶Stock offered public June, 1956.
**Includes non-consolidated companies personnel.
For consolidated companies only.



At 1957 Power Fair, engineers witness proof of...

TURBO-UNIFLO PERFORMANCE

There's no better way to judge the performance of an engine than to see it in operation. That's why more than 250 process and pipeline engineers recently gathered in Buffalo, N. Y., to attend Worthington's 1957 "Power Fair."

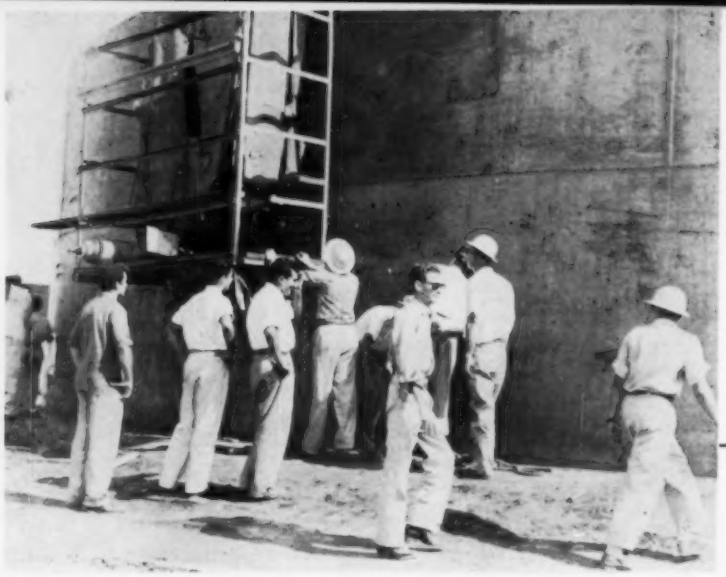
Star of the show was the new SUTC TURBO-UNIFLO gas engine compressor. The only two-cycle engine compressor with exhaust powered turbocharging from start-up through full-load, the TURBO-UNIFLO features remarkable stability over the complete range of speed and load requirements.

The audience was impressed by the TURBO-UNIFLO's smooth start and quiet operation (as much as 20 decibels quieter than engines with mechanically driven scavenging systems). Next came the overload demonstration to prove the very conservative engine rating.

To show stability, engine speed was gradually reduced while maintaining full torque. 320 rpm . . . 270 rpm . . . 230 rpm (at this point someone offered to bet that it couldn't go below 150). But down it went . . . all the way to 105 rpm before reaching its stalling point.

But this is only half the story. Your Worthington representative will be glad to give you all the facts about the new SUTC TURBO-UNIFLO engine. Get in touch with your nearest Worthington district office or write to Section E-73, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Brantford, Ont. E-73

WORTHINGTON



At Zulia University Petroleum Engineering School students take time out to visit field installations and get first hand information on actual operations. The school at Maracaibo is within short distance of one of the world's largest oil-producing areas and installations. Enrollment in petroleum engineering is gaining rapidly at University of Zulia. During 1954-55 26 students were enrolled, the following year 46 registered, and last year 72 were in attendance. For the year 1957-58 it is expected that 130 students will be taking petroleum engineering.

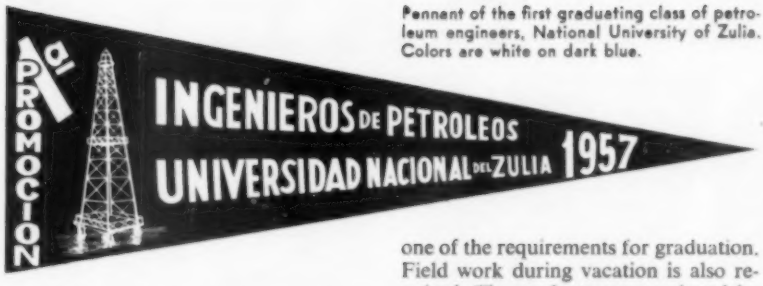
EDUCATION on the Oil Front

University of Zulia at Maracaibo combines classes and field work to prepare students for petroleum engineering degree . . . good teachers, interested cooperation of both school and petroleum companies attract some 130 young Venezuelans to new curriculum in oil city

ELEVEN boys and one girl were graduated in the first class of the School of Petroleum Engineering at the National University of Zulia in 1957. These 12 young Venezuelans received their diplomas July 24. All of them had scholarships granted by the government and by the oil industry.

This is the beginning of an effort to fulfill a great demand for engineers in the petroleum industry. Although a number of engineers — mechanical, electrical, etc. — are graduated from Zulia University and from Central University in Caracas, few of them find their way into petroleum industries.

Members of the first graduating class of Petroleum Engineering, National University of Zulia: Front row: Pedro Rios, Socony Mobil Oil Company of Venezuela scholarship; Arevalo G. Reyes, Core Laboratories de Venezuela; Hugo Vivas, Dilcia Ramirez Lugo, Lucio Peralta, and Lindolfo Leon Rodriguez, Compania Shell de Venezuela; Ernesto Agostini and Francisco Guedez, Ministry of Mines and Hydrocarbons; Back row: Mauricio Tedeschi, Ministry of Mines and Hydrocarbons, Pedro Luis Diaz, Socony Mobil; Jose U. Ramirez Olmos, Ministry, and Edgard Valero, Creole Petroleum Corporation. Each member of this class was provided with a scholarship.



Pennant of the first graduating class of petroleum engineers, National University of Zulia. Colors are white on dark blue.

Most of them now go into construction work.

The School of Petroleum Engineering at Zulia University is not the first one opened in Venezuela, but it appears to have a sounder foundation than the earlier attempt. Back in 1944 a petroleum engineering school was closed and has not been reopened. Caracas University does offer courses for other kinds of engineering.

The fact that the University of Zulia is at Maracaibo, close to the booming Maracaibo Basin, gives it a background more conducive to success. It was established September 4, 1952, after considerable study on the needs for technical manpower in the petroleum industry. University officials, the Ministry of Education, and the industry itself supported the new school.

Another boost was given the school in 1954 when Ing. E. E. Barberii, experienced teacher and practicing engineer, became director of the Zulia Petroleum Engineering School. Ing. Barberii was educated at the University of Oklahoma and for four years was a member of the faculty of petroleum engineering at Tulsa University in Oklahoma. Some of his students from Tulsa University are now employed by oil companies in Venezuela.

He was on the Creole engineering staff and later was chief petroleum engineer of Mexican American Independent Company in Mexico. Others on the faculty are Venezuelan, American, and European universities graduates, with long experience in the oil business in Venezuela and other countries. Special lecturers from industry give the students first hand information in exploration, drilling, production, refining, transportation, sales, and administration practices.

The study program compares favorably with similar curricular offered by schools in the United States. The five-year course on a unit basis is distributed by subjects as follows: Mathematics 20, chemistry 9, physics 9, geology 12, mechanics 10, language and humanities 14, mechanical engineering 11, civil engineering 12, electrical engineering 6, chemical engineering 10, administration 5, petroleum engineering 34. Total: 152 units.

The student must write a thesis as one of the requirements for graduation. Field work during vacation is also required. The students are employed by different companies in Venezuela.

The theoretical approach to each subject is presented in the classroom. Solutions of field problems are demonstrated by students in class and in the laboratory so that they may appreciate more fully the role of the engineer in actual operations.

By special donations of government and contributions of oil and service companies the school has modern buildings and equipment. Generous scholarships are offered by the companies and the University to deserving students. The school hopes to attract Latin-American students from other countries, and already has request for admission from Argentina, Brazil, Peru, and other nations. ★ ★ ★

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Beck Oil Company's rig No. 2 now operating on the Texas Gulf Coast. These are the 6-110 GM Diesel Twins that provide the punch for the Beck rig drawworks.

On Gulf Coast, GM Diesel Engines "Get With It!"

The Beck Oil Company is noted for its efficient drilling and production operations. Beck operates three rigs. The company this year will drill about 55 wells. That's a prodigious schedule . . . and that schedule will be realized with STEWART & STEVENSON SERVICES GM DIESEL POWER.

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"Our experience has been lots of footage, fast trips and power to spare. We'd rather run an engine at two-thirds power than one at full power. That reserve sometimes makes the difference."

An example of the power Mr. Beck has reference to is on Rig No. 2, operating now in Liberty County, Texas. The drawworks is powered by two 6-110 GM Diesel Twins. That power enables the boys to "get with it."

With Stewart & Stevenson power, dependability is a guarantee.

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USSR Oil Industry to Try Decentralization

Charles L. Adams

Mistakes include: Petrochemical plant took 10 years to build; lack of parts idles refinery; oil and gas workers ride separately to same field

DIRECTORS of Russia's regional and local oil industry enterprises—including drilling, producing, and refining organizations—have strongly endorsed Communist party chief Nikita Khrushchev's plan for administrative decentralization.

The new program, recently approved by Russia's Supreme Soviet, provides, in theory at least, for transferring management authority from the highly-centralized USSR Ministry of the Oil Industry's Moscow headquarters to the regional level.

Separate oil ministries are planned for the huge Russian Soviet Federated Socialist Republic, which includes the entire "Second Baku" area, and for several of the smaller republics with well-developed petroleum industries, such as Kazakhstan and Turkmenia. The Azerbaijan republic has had its own oil ministry since 1954, and the arrangement reportedly has helped improve Baku's output.

Khrushchev criticized the concentration of oil industry bureaus and scientific institutes in Moscow which, he noted, is far removed from Russia's oil producing regions. He suggested that headquarters for the new Russian Soviet Federated Socialist Republic oil ministry be moved from Moscow to Kazan or Ufa — cities in the booming "Second Baku" area.

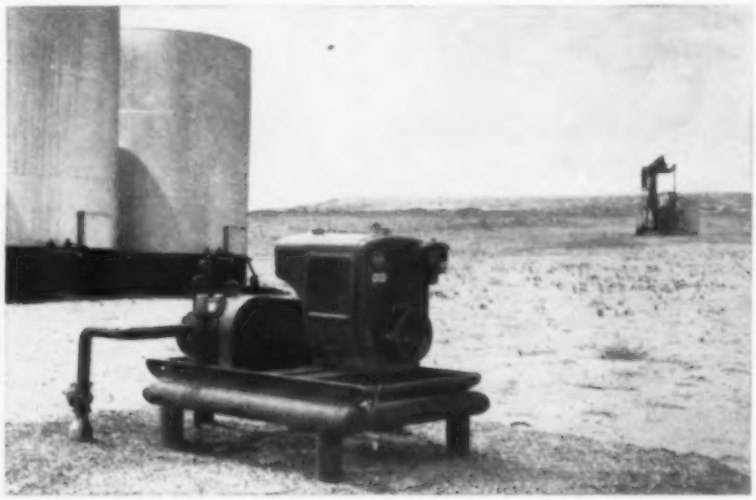
In discussing the need for administrative reorganization, Z. N. Nuriev, a Supreme Soviet deputy from Bashkiria (part of the "Second Baku" region) charged that departmental disputes and artificially-created barriers in the old USSR Ministry of the Oil Industry had caused an "intolerable lag" in development of his area's petrochemical plants.

N. Trupanov, an employee of the Novo-Ufa refinery in the city of Ufa, wrote the newspaper *Pravda* that Khrushchev's plan promised to bring some badly needed order out of administrative chaos. He noted, for example, that because of departmental bungling his refinery's "plan" for the first quarter of 1957 called for delivering only half as much of certain oil products as could have been produced. "For this reason, our refining capacity was not fully used."

Trupanov complained that because of the Moscow oil ministry's disinterest, one petrochemical plant took almost 10 years to build, "during which time colossal quantities of by-product gas went to waste." He said that owing to poor contact between the central administration and the Novo-Ufa refinery, spare pump parts were not delivered and a cracking unit was idled for a month.

"There are," he concluded, "many such instances."

In the Saratov area, officials expressed hope that the new administrative setup would permit oil workers and gas workers traveling the same road to the same producing field at the same time to ride together in the same trucks instead of traveling in different trucks provided by their respective oil and gas organizations. ★ ★ ★



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The gathering pump installation, shown above, is a typical Wisconsin-powered oil field unit. The Model THD 2-cylinder Wisconsin Power Unit, belted to a Roper pump, has a capacity of 60 barrels at 200 lbs. pressure.

You can't do better than to specify "Wisconsin Power" for your oil field utility units.

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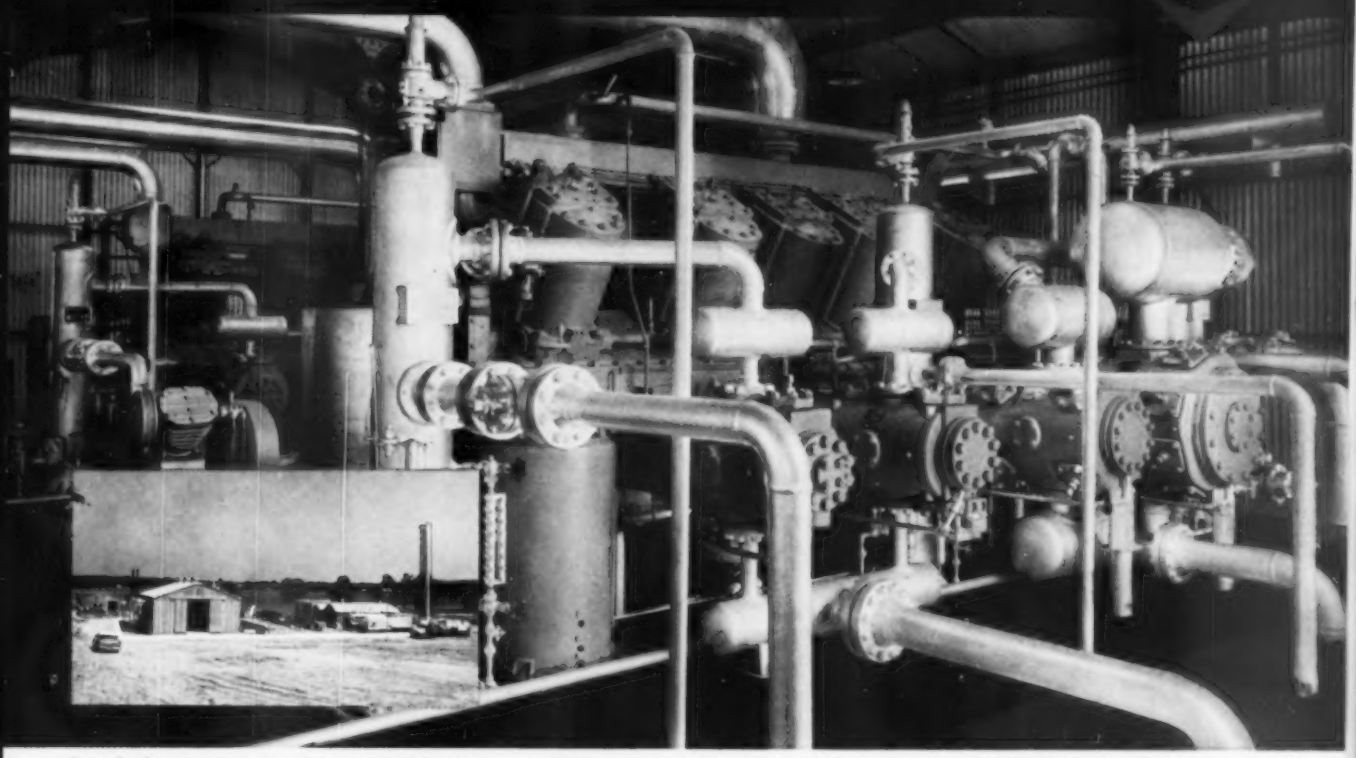
BEAIRD-INGERSOLL-RAND Packaged Compressor Plant



Tatum Gas Plant equipped with two Beaird-Ingersoll-Rand 10SVG 550 h.p. packaged compressors. Units are complete with all necessary controls for unattended operation. Other sizes from 120 to 660 h.p.

Packaged Compressor Equipped . . .

GAS PROCESSING BOOSTS FIELD ALLOWABLES

Robert Cargill, operates this gas processing plant in the Tatum-Petit Field. Located just outside the city limits of Tatum, Texas, the field has grown from a single wildcat to 75 producing wells in less than three years. During this swift expansion it became evident that the increasing number of high gas-oil ratio wells would curtail oil production unless a means was provided to conserve the excess gas. An additional problem was created by the wide variation of wellhead pressures which ranged from 25 psig. to 650 psig.

Engineers called in by Robert Cargill solved the production problem by designing a gas processing plant to remove heavy elements as marketable by-products and to boost the dry gas to a nearby sales line. Two Beaird-Ingersoll-Rand 10SVG 550 horsepower packaged compressors were selected for the main station. Each compressor has been engineered to handle both low and high pressure streams. Low pressure gas is boosted through three compression stages then tied into the discharge of the fourth cylinder which boosts the high pressure stream. The plant can process 20 mmcfd. at 850 to 1,000 psig. discharge with its present arrangement.

As future requirements demand, additional packaged units may be economically installed to handle the increased load. When the field is depleted the compressors may be moved to other service with little or no change in piping or manifolding.

Let us assist you in planning an economical solution to your production problem. Call or write . . .

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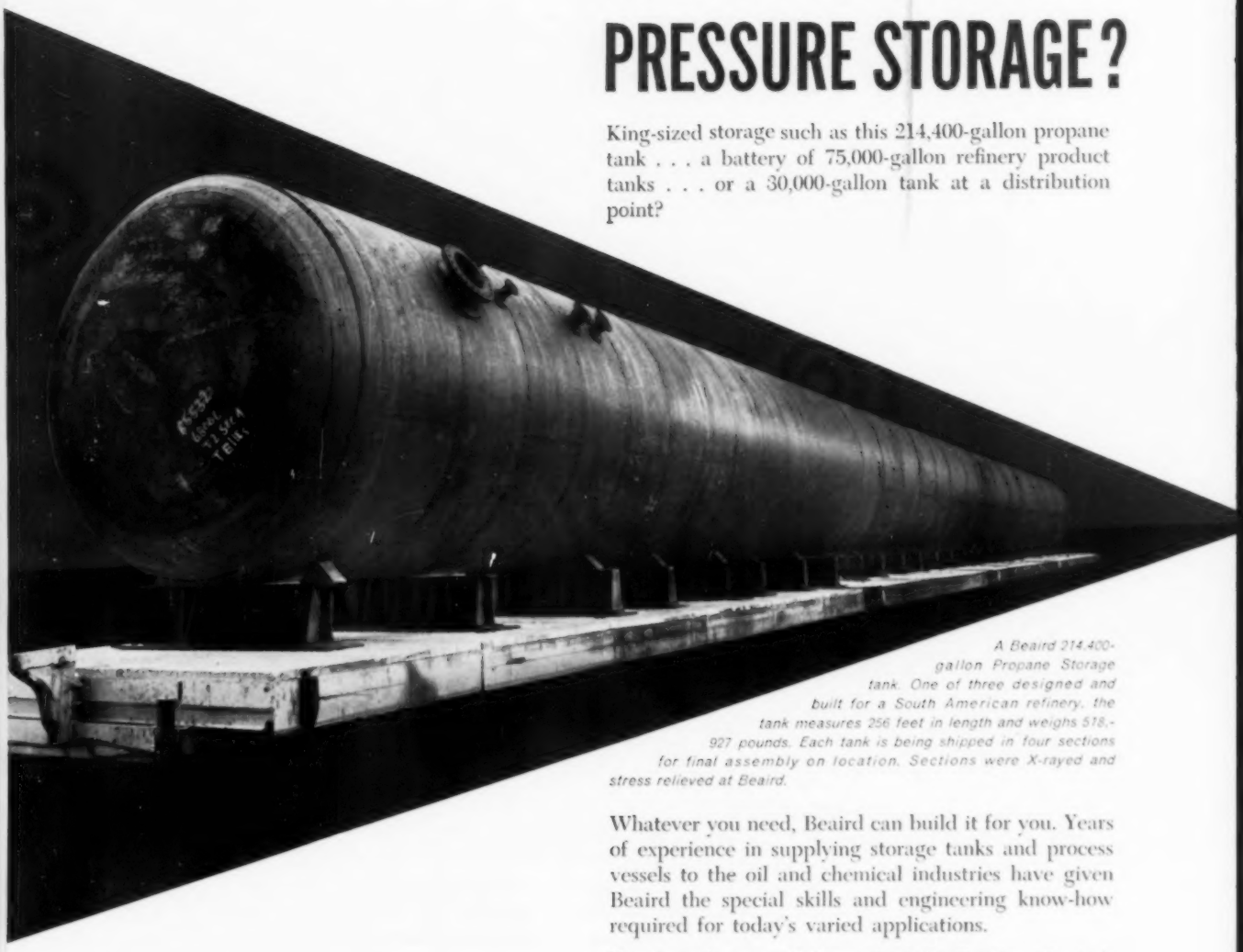
King-sized storage such as this 214,400-gallon propane tank . . . a battery of 75,000-gallon refinery product tanks . . . or a 30,000-gallon tank at a distribution point?



A Beaird 214,400-gallon Propane Storage tank. One of three designed and built for a South American refinery, the tank measures 256 feet in length and weighs 518,927 pounds. Each tank is being shipped in four sections for final assembly on location. Sections were X-rayed and stress relieved at Beaird.

Whatever you need, Beaird can build it for you. Years of experience in supplying storage tanks and process vessels to the oil and chemical industries have given Beaird the special skills and engineering know-how required for today's varied applications.

You benefit as well from Beaird's Quality Control. Modern X-ray equipment, hydrostatic testing, stress relieving facilities, full-time insurance inspectors and strict adherence to fabricating code procedures all play important roles in building Beaird pressure storage.

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Management Personals

Dr. Giacopini

▸ **Dr. Jose Antonio Giacopini Zarraga,** former head of public relations, has been named assistant to the president of Compania Shell de Venezuela Ltd. **Dr. Rafael Morello C.** was appointed manager of general affairs. Until recently, he had been field superintendent. The

Dr. Morello

Dr. Rosales

new head of public relations is **Dr. Cesar Miguel Rosales W.,** who had been assistant superintendent in the La Concepcion district until this year.

▸ **Richard M. Johnson** has been elected a vice president of Cosden Petroleum Corporation. Johnson continues a director of sales held since 1953. The board of directors have created the office of senior vice president, electing to that post **Marvin M. Miller,** head of the producing division, and **Dan M. Krausse,** head of the refining division. **Joe A. Moss** was elected assistant secretary and **R. O. Satterwhite,** assistant treasurer.

▸ **James Robert Riggs** is with Kerr-McGee Oil Industries, Inc., as manager of systems and procedures. Riggs formerly was assistant supervisor, accounting department, Standard of Indiana.

▸ **Irvine Pollock** was named regional manager, Houston, Texas, of The Texas Company's technical services division. Before taking his new assignment Pollock was technologist in Texaco's Chicago technical services headquarters.

▸ **John J. H. Phillips,** former senior account executive with Benton & Bowles, Inc., advertising agency in New York, will head Ohio Oil Company's expanded advertising—sales promotion department.

▸ **G. H. Herridge** was named managing director of the Iraq Petroleum Company and its associated companies and **H. W. Fisher** an executive director with the title of joint managing director.

▸ Gulf Oil Corporation announces the following appointments in London: **Colonel F. T. Davies,** vice president, Gulf European Company as group coordinator; **A. Greersen** as vice president, production, Gulf Eastern Company; **L. Gombos** as counsel for Eastern Hemisphere; **S. V. Gasperina** as assistant comptroller, Gulf European Company; **R. B. Hoffman** as marketing manager, Gulf Eastern Company; **R. F. Temp** as crude oil sales manager, Gulf Eastern Company; **R. G. Martin** as transportation manager, Gulf Eastern Company, and **P. H. Boersig** as assistant treasurer, Gulf European Company.

▸ **Guy B. Hunter,** chairman of the board of Quaker State Oil Refining Corporation, Oil City, Pennsylvania, was re-elected president of the National Petroleum Association. This will mark Hunter's third term as head of the association of oil refiners. **Paul R. Beck,** of Pennsylvania Refining Company, Butler, Pennsylvania, was re-elected first vice president, and **Rexford S. Blazer,** of Ashland Oil & Refining Company, was re-elected second vice president. Hunter is also treasurer. **E. M. Lyons** was re-elected recording secretary, and **Margaret A. Miller,** assistant treasurer and executive assistant.

▸ **Robert W. Ward,** Lovington, New Mexico attorney and president of the Lea County Bar Association, was elected vice president of Shelton-Warren Oil Co.

▸ **Jess E. Hendricks,** for the past 9 years manager of gas, gasoline and refining departments for H. L. Hunt, independent oil and gas operator, has joined the executive staff of Coastal States Gas Producing Company as manager of operations.

▸ **Myron O. Johnson** is manager of a new computing department, Phillips Petroleum Company. He was formerly assistant manager of supply and transportation.

▸ **Leroy D. Stinebower** and **David J. Jones** were appointed assistant treasurers of Standard Oil Company (New Jersey). Stinebower, who has been European financial representative in London for Jersey, will be succeeded in that post by **Lester B. Johnson,** now an assistant treasurer of the company. Jones was financial manager of Esso Standard S.A.F. Johnson has been an assistant treasurer of Jersey.

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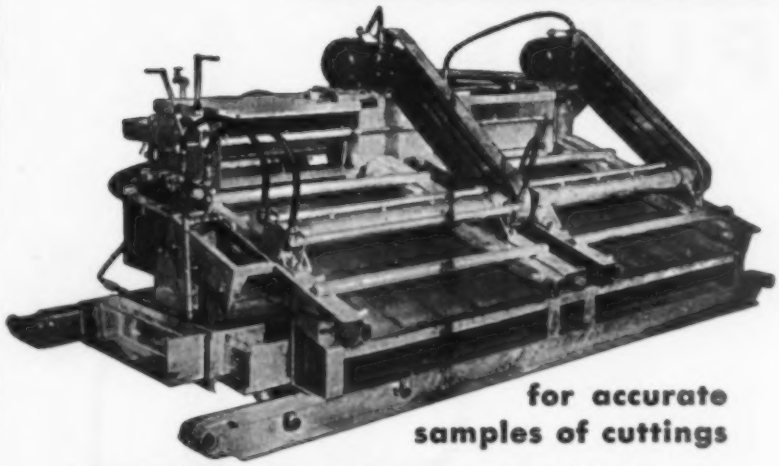

for accurate samples of cuttings

The THOMPSON SHALE SHAKER SAMPLE MACHINE offers the operator and geologist one of the best methods available for obtaining accurate foot-by-foot samples of well cuttings.

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Personals

▸ **Willard W. Stewart** was named financial advisor to the executive representative's office of International Petroleum Company, in Bogota, Colombia. He was formerly manager of the treasury department in Lima, Peru. **Irving H. Taylor Jr.,** acting financial advisor to the executive representative, will replace Stewart. **Albert E. Bruggemeyer Jr.,** financial analyst, was named manager of the treasury department (Colombia). **David H. Mortlock** was made economics advisor to the executive representative's office. He was previously with Arabian American Oil Company. **Taylor E. Little** is new employee relations department head, Talara, Peru. He was employment supervisor in the employee relations department at Coral Gables, Florida. In his new position in Talara, Little replaces **W. E. Moore,** who has become administrative superintendent at El Alto.

▸ **Thomas F. Brawner** was appointed assistant to director of public relations for The Texas Company at Houston. He joined Texaco in 1946 as public relations representative at Houston.

▸ **Herbert F. Lindsay** is manager of Tidewater Oil Company's newly established electronic computer department. He previously headed a team of researchers and analysts formed last year to develop a company-wide program for operations research and electronic data processing.

▸ **J. B. Saunders** of Houston and **Breene M. Kerr** of Oklahoma City, were elected to the board of directors of Kerr-McGee Oil Industries, Inc. Saunders is president of Triangle Refineries, Inc., of Houston, a company acquired this spring by Kerr-McGee. Kerr is a son of Senator Robert S. Kerr, founder and chairman.

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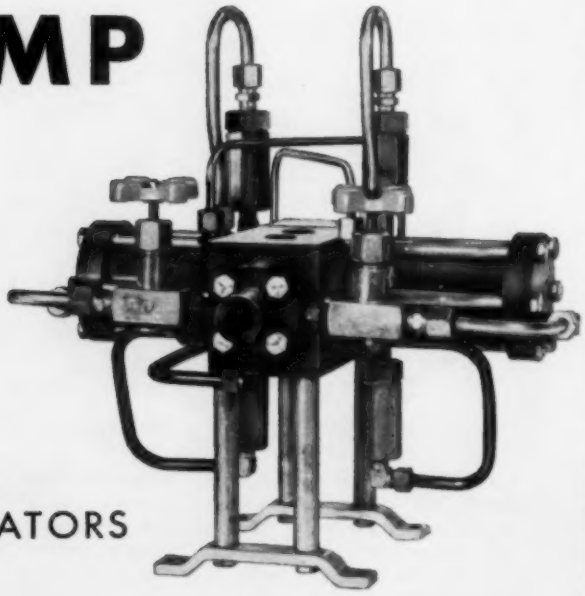

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PV Series – Capacities from 40 G.P.H.

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▸ **George T. Culp** was appointed head of the employee relations group of Creole Petroleum Corporation's New York office. He replaces **Milton C. Hagen** who transferred to Standard Oil Company (New Jersey) as overseas advisor.

▸ **W. C. Connel** was appointed purchasing agent for BP Trading Ltd. **J. E. Anderson,** formerly purchasing agent is returning to London to take up another appointment with the parent company, The British Petroleum Company Ltd.

▸ **G. H. Naylor,** formerly chief accountant of Magnolia Petroleum Company, was appointed assistant to the comptroller, **L. E. Frensley.** His duties will include co-ordinating the staff departments of methods research, data processing procedures and tabulating departments.

▸ **Charles W. Alcorn,** Houston, independent oil producer and drilling contractor, is the 16th president of the Texas Mid-Continent Oil & Gas Association. Alcorn, 59, executive vice president of Falcon Seaboard Drilling Company, succeeds **French M. Robertson,** Abilene independent producer, who held the post two years.

C. W. Alcorn

J. E. Rouse

▸ **John E. Rouse,** Denver oil executive, was elected president of Utah Southern Oil Company. **George T. Hansen,** Salt Lake City, founder and president, was elected chairman of the board. **George T. Hansen Jr.,** Salt Lake City, was named vice president in charge of operations, **De Witt Van Evera,** Salt Lake City, to continue as treasurer, and **M. D. Paine,** Salt Lake City, as secretary.

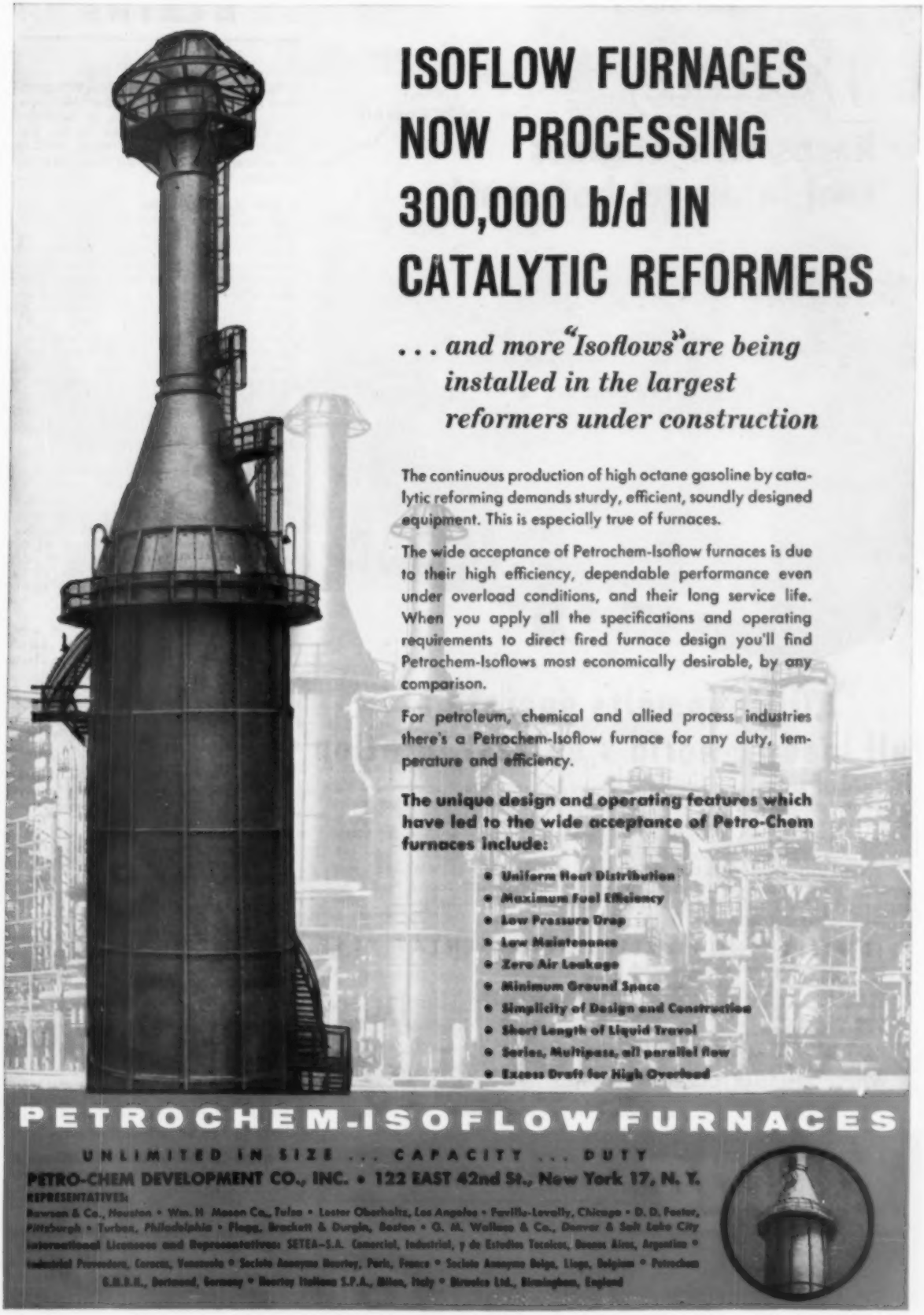
▸ **Kerryn King** was named general manager of the industrial and public relations department of The Teras Company. He was formerly assistant general manager

Kerryn King

T. D. Durrance

and director of public relations. He will be succeeded as director of public relations by **Thomas D. Durrance,** who has been supervisor of editorial services. **Robert T. Kenney** and **Thomas F. Brawner** were named assistants to the director of public relations with headquarters in Los Angeles and Houston, respectively.

▸ **Paul E. Klopsteg** was appointed associate director for research of the National Science Foundation. He was formerly an associate director of the foundation and more recently served in a consultative capacity.



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1,000 hp units operate at full load in world's hottest location

Not even the fierce heat of Kuwait or general water shortage in the area can impair the efficiency of the Young equipment used to cool the jacket water, supercharger intercooler water and engine oil on th ngines of the four 1,000 hp pumping units designed and built by the Enterprise Division of General Metals Corporation of San Francisco.

Young equipment identified above: (1) Radiator Model MWC-455 with separate cooling sections for jacket water-supercharger intercooler water and engine oil. (2) Young Mono Weld® construction turbo-charged air intercooler. (3) Model OCS-300 Torque Converter Cooler.

OIL FIELD AND PIPELINE REPRESENTATIVES

1. Central Station Equipment Co. Tucson, Arizona
2. Flournoy & Everett, Inc. Downey, California
3. Jones and Laughlin Bradford, Pennsylvania
4. J. R. Mesk Company Tulsa, Oklahoma, Houston, Texas
5. Frank Walz Denver, Colorado
6. Dutton-Williams Bros. Ltd. Calgary, Alberta, Canada
7. H. J. Young Muskegon, Michigan

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Young RADIATOR COMPANY

RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

DEATHS

Melbert Edgar Schwarz, 59, a vice president in charge of all oil production operations, domestic and foreign, of Seaboard Oil Company, died October 13. He was about to deliver a speech when stricken by a heart attack. He had been with the company since 1933.

Erle P. Halliburton, 65, founder and chairman of Halliburton Oil Well Cementing Company, Duncan, Oklahoma, died October 14 in a Los Angeles hospital. He underwent surgery for a respiratory ailment. In 1921 he went to Duncan with an idea he could cement oil wells under water pressure, proving his belief by cementing a wild well for the late W. B. Skelly. Founded in 1924, with 56 employees and an initial capitalization of $350,000, Halliburton Oil Well Cementing under Mr. Halliburton's leadership, grew into one of the world's largest oil service organizations. At the time of his death, annual sales amounted to $176,000,000. He had not been active for several years.

R. C. Baker, 85, founder and chairman of the board of Baker Oil Tools, Inc., died September 29, at Whittier, California. A pioneer in California oil activities, Mr. Baker was a drilling contractor and oil operator shortly after the turn of the century. The Baker Casing Shoe was founded in 1912 to market oil tools of his invention and subsequently became Baker Oil Tools.

Philip J. Wenz, 63, manager of service and repair division of De Laval Steam Turbine Company, Trenton, New Jersey, died on September 11.

Luther L. Clark, scout for the Carter Oil Company before his retirement in February last year, died early in the week of October 6.

W. E. "Bill" Powell, 39, general manager for Birdwell, Inc., Bradford, Pennsylvania, died September 14, as a result of an automobile accident.

Jon Paul Jones, 45, well-known Tulsa opera performer and vice president of the Ranger Petroleum Company, died of a heart attack September 30 in East Lansing, Michigan.

John H. White, 63, assistant secretary and purchasing agent for Blanco Oil Company, of San Antonio, Texas, died of a heart ailment October 7.

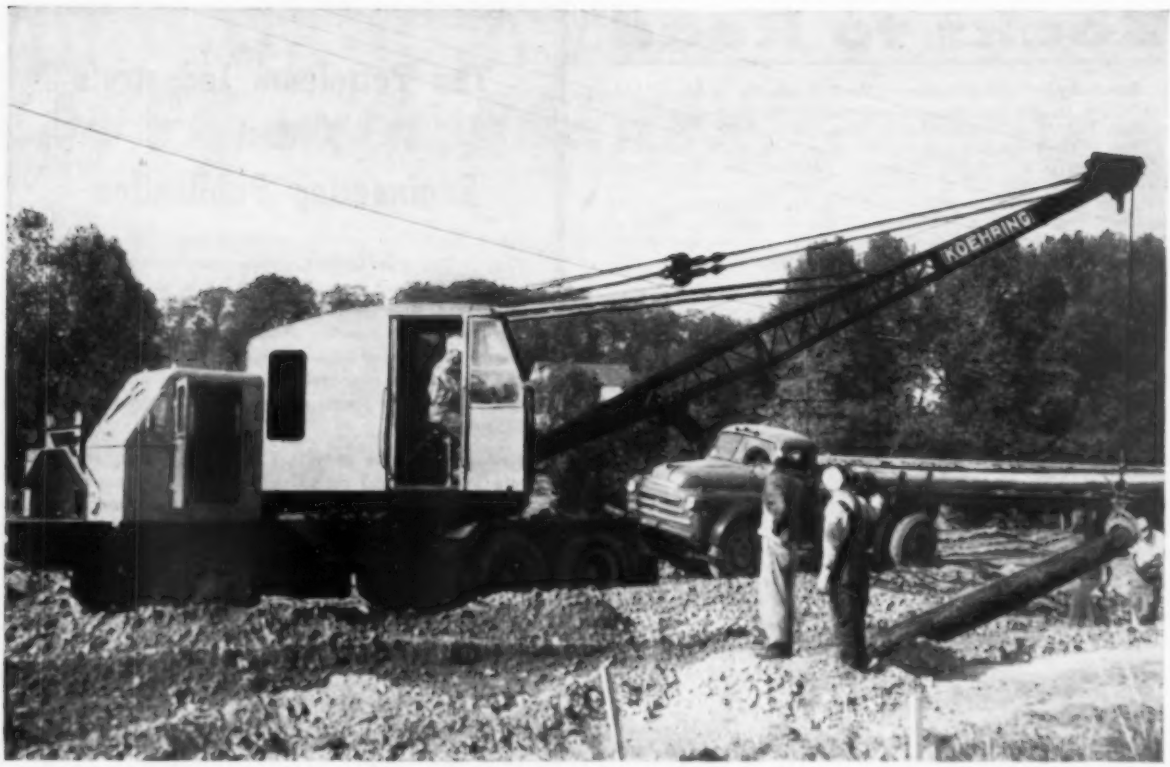
H. G. Cornew, 60, special representative-foreign trade department, Standard Oil Company of California, died September 17 following a short illness.

J. H. "Bert" Cornell, commercial manager and a director of The Photographic Survey Corporation, of Toronto, died October 1 in Caracas, Venezuela.

Roger L. Dailey, division manager of the eastern division of The National Supply Company, died suddenly September 4 at Toledo. He was 57 years old.

Franklin R. Hoadley Sr., 67, a retired president of Farrel-Birmingham Company, Inc., Ansonia, Connecticut, and a former president and treasurer of Atwood Machine Company, Stonington, Connecticut, died of a heart attack September 12.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



On lifting and material-handling work, where distance between jobs is a problem, take advantage of the speed, mobility, and *extra capacity* of Koehring 205 Truck Crane. It travels anywhere a truck will go — can be 30 to 40 miles from here in less than an hour from "now".

With one of these mobile cranes, you're equipped to lift any load up to 15 tons (based on 85% of tipping load). For high lifts, 25-foot boom can be lengthened to 70 feet. For extra reach, 15 to 30-ft. jib can be added to 65-foot boom. Stability of truck mounting increases the 205's work capacity with every attachment. It handles ½ to ¾-yard clamshell or dragline buckets on a wide work-radius — and quickly converts to ½-yard shovel or hoe.

This heavy-duty 205 also is available as a 15-ton Cruiser® crane, or 10-ton crawler crane — with all standard attachments. On rubber-tired Cruiser mounting, it brings you travel speeds up to 21½ m.p.h. — plus one-man operation for both work and travel.

Next time you're in the market for a crane or excavator, look into this 205. Your Koehring distributor has complete facts and figures that will interest you. Why not call him today? Or, use coupon to get complete information by mail.

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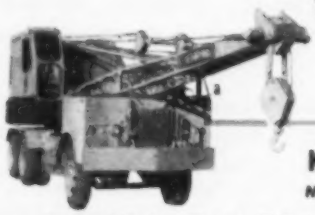

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Books to Read

Occurrence of Oil and Gas in West Texas, *Publication 5716, published by the Bureau of Economic Geology, University of Texas, Box 8022, Austin, Texas. Pages, 456. Price, $10.*

This is the second in a series on occurrence of oil and gas in Texas and is a cooperative project between the West Texas Geological Society and the Bureau of Economic Geology. Publication includes descriptions of 112 fields, and papers of 104 authors giving structure maps and graphic typical section of rocks penetrated, with electric log. Cross sections are shown for several fields. There are three large maps.

Oil and Gas Leasing on Federal Leasing, *by Lewis E. Hoffman, published by F. H. Gower, 2240 Mile High Center, Denver 2, Colorado. Pages, 650. Price $10.50.*

This is a revised edition of *Oil and Gas Leasing on the Public Domain,* published in 1951. Many changes and several chapters have been added to the new book brought about by alterations in laws and regulations since the first volume was written. The author is an authority on the subject; he is Minerals Staff officer with the Bureau of Land Management, Washington, D. C.

Conservation in the Production of Petroleum: A Study in Industrial Control, *by Dr. Erich W. Zimmerman. Published by the Yale University Press, New Haven, Connecticut. Pages, 417. Price, $6.*

This represents Volume 2 in the Petroleum Monograph series established by a grant from the American Petroleum Institute. It explores the oil and gas conservation program in the U. S. in the last 25 years, noting its development, advancements and achievements. The author reviews its legality, exposes its problems and lists its facets.

Kodak Materials for Geophysical Exploration, *published by Eastman Kodak Company, Rochester 4, New York. Pages 32. Price, $0.35.*

This new booklet, which replaces the firm's *Kodak Recording Materials,* is the first of several new data books. It describes Linagraph papers, films and chemicals, and gives information on other related products used for geophysical exploration. There are sections on basic processing data, record duplication.

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LAUGH with BARNEY

Tommy, age five, and the oldest of five children, awakened from a tonsil operation to ask, "Where's my baby?"

* * *

Most old maids are born, and not made.

* * *

In golf, it's distance.
In a cigarette, it's taste.
In a Crosley—it's impossible.

* * *

"Jarvis, why didn't you put out my gloves tonight?" the bachelor asked his butler.

"But sir, you said you were calling on a lady and I thought you would feel better without them."

* * *

The couple signed the hotel register and asked the clerk for the best accommodations. He recommended the bridal suite.

"Why the bridal suite?" said the young man. "My wife and I have been married for five years."

"Look," said the clerk, "If I let you have the main ballroom that doesn't mean you have to dance, does it?"

* * *

Lady: "Is your husband broadminded?"
Wife: "Yes, the old goat! That's all he seems to think about."

* * *

It was said of a particularly obnoxious fellow: "He has a contagious smile—trench mouth."

* * *

A toolpusher died and went to Heaven. He wanted to meet Adam and Eve, but he couldn't find them in the milling crowd. One day he met a landman he had known on earth that was famous for his "scouting" ability. He asked him to find the famous couple for him. The landman returned a little later and told him where he could find them. "How will I know them?" he asked.

"Oh, it's simple. Just look for two people without belly buttons."

* * *

Little Johnny is at that in-between age. He knows why strapless evening gowns are held up, but he doesn't know how.

* * *

Husband: What's my wife paying you to paint the kitchen?"
Painter: Oh, it's all piece work.

* * *

Do you know what one dog said to the other? "Hurry and sit down, here comes old cold nose!"

Been to a men's smoker lately? Send your stories to: Barney, Box 1589, Dallas 21, Texas.

* * *

Bob Scott of Fruita, Colorado, sent Barney these:

"Mother," said the young bride of a week, "I'm puzzled. When do men sleep?"

A middle aged motner with her 20-year-old daughter were driving and, being anxious to cover as many miles per day as possible, loaded the lunch box with various cold meats and sandwich spreads, instead of stopping for lunch at a cafe. When noon came they discovered that they had forgotten to include a loaf of bread.

They stopped at a small country crossroad store, and the old gray-haired man who ran it was sitting on the front porch. He said to them, "Wal, what'll yourns be?" The mother replied, "I want Merita Bread." He looked at them for a minute and said, "Lady, I'm 68 years old, but if that's her in the front seat with you, fetch her in."

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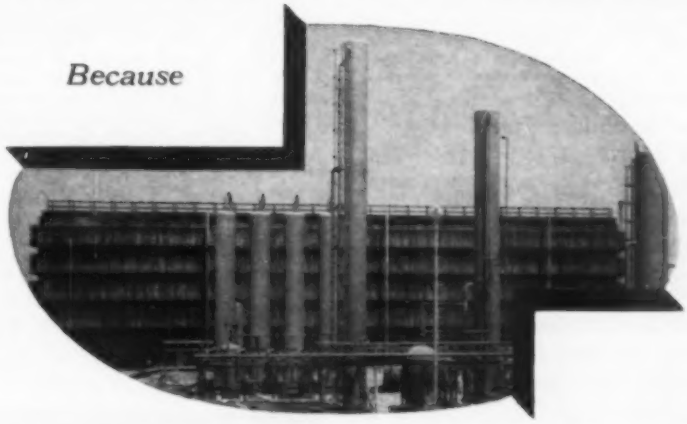

In Corrosion Inhibitors There Is A Difference

A difference which can be used to your advantage is present in the chemical composition and behavior of Haering's Organic Chrom Glucosates*.

A Chrom Glucosate* inhibitor film is tough, tenacious, elastic yet adherent, self-sealing and impervious. Is particularly effective in waters with high sulfate and chloride contents** or where process streams introduce various complex reducing contaminants. The organic Glucosates are used at low dosage rates over wide ph range. No more expensive and often cheaper to use.

Without cost or obligation find out how "Organic Methods" can provide extraordinary protection to water-using equipment in your plant.

**In use 8 years in a Cooling System where chloride content exceeds 25,000 ppm at times.

*Reg. U. S. Pat Office

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• Industry
• People
• News

The Trade PARADE

R. G. LeTourneau, left, president of R. G. LeTourneau, Inc., presents a 20-year service award pin to Vice President R. L. LeTourneau, during plant ceremonies at company headquarters in Longview, Texas.

New Seamless Tube Mill Starts

Operations have begun at the Youngstown Sheet and Tube Company's new seamless tube mill, located at the Indiana Harbor Work. Seamless pipe output will be directed primarily to oil-well casing. Sizes ranging from 4½ to 9⅝ in. in outside diameter will be made.

25th Anniversary of High Alloy Foundry Industry

Twenty-five years of continuous metallurgical research activity were marked by Bradley B. Evans, retiring president of the Alloy Casting Institute, at its annual meeting in Hot Springs, Virginia. Of special interest to members and guests was the report by P. R. Gouwens, chairman of the ACI Technical Research Committee, who reported the successful development of a high-strength cast corrosion resistant alloy, which has aroused great interest in the chemical processing and many other industries.

At the close of the meeting, F. M. Fahrenwald, president of the Fahralloy Company, was elected president of the Institute. Elected vice president was Paul L. McCulloch, Jr., president of the Electro-Alloys Division of the American Brake Shoe Company.

200 to Attend Automation School

Nearly 200 engineers and technicians will be enrolled in classes on industrial control instruments this fall at the Instrumentation Education Center conducted by Minneapolis-Honeywell's Industrial Division. Students represent 65 U. S. industrial firms and 14 government agencies and 14 foreign companies in 4 countries. Curriculum for the tuition-free classes, which run from 2 to 13 weeks, includes courses in pyrometry, electric potentiometers, pneumatic control and transmission, flow meters, thermometers and pressure gages. The center, opened in 1935, now has more than 5000 graduates.

Maintenance School on Wheels

Two vans containing nearly $50,000 worth of tractor assemblies and components are bringing a complete "factory" service training school directly to J. I. Case Industrial dealers. An experienced staff accompanying each mobile training unit will present 3-day courses in maintenance and service of Case Terra-Trac wheel and crawler tractors and equipment. One unit is now operating in the mid-west and far-west, while the other visits the eastern and southern U.S.

CARRIER-MICROWAVE DEPARTMENT of Westinghouse Electric Corporation in Halethorpe, Maryland, has constructed a new, modern office building adjacent to the manufacturing plant. Administrative, sales, engineering, purchasing, and accounting offices are now located in the one building.

AMPCO METAL, INC., WILL BUILD a $200,000 branch foundry at Garland, Texas. The 15,000 sq ft plant will include sand and centrifugal foundries, heat treating facilities and some machining operations. It also will become the location of Ampco's principal sales and services offices in the Southwest.

G&H TOWING COMPANY OPENED an office in New Orleans. This office will coordinate G&H tug services to the oil industry for tidelands and deep sea towing from ports along the Louisiana coast.

HARBISON-FISCHER MANUFACTURING Company, Fort Worth, has opened a new warehouse in Wichita Falls, Texas. Clyde Snody is in charge of the new facility.

The Casper, Wyoming, store of the George E. Failing Company has moved into a new building on the outskirts of Casper. E. E. (Pete) Martin is district manager in the Rocky Mountain area for Failing.

TRANSFER OF OPERATIONS TO NEW three-quarter million dollar plant in King of Pressia, Pennsylvania, and change of name from The Automatic Temperature Control Company to Automatic Timing & Controls, Inc., has been completed. A subsidiary of Safety Industries, Inc., the new name, Automatic Timing & Controls, Inc., chosen from many suggestions made by employees, is more descriptive of the several product lines manufactured. Their 3 basic product categories include precision timers, for the control of industrial processes, "Atcotran," electrical and electronic equipment, used in the building of control systems for automation, and mechanized valve operators.

THE NATIONAL SUPPLY COMPANY will move its southwest division offices to Dallas, Texas. Company will occupy the entire fourth floor in the Dallas Federal Building.

The fifth group of Republic Supply Company's store managers has completed a special training conference at the general office in Oklahoma City. Attending the conference were Messrs. D. H. Darland, Electra, Texas; S. E. Long, Rodessa, Louisiana; C. R. Hines, Odessa, Texas; E. E. Copeland, Abilene, Texas, and Jerry Norwood, Sundown, Texas. Mr. George Steinmeyer conducted the management course.

SAVING LIVES AND MONEY

The prevention of injuries to workers should be a basic concern of every employer. Accident prevention eliminates needless suffering, promotes better employee morale with less turnover, improves efficiency, and helps reduce the cost of workmen's compensation insurance. Regardless of where you insure, the responsibility, initiative and interest in safety must come from within your organization if real results are to be obtained.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

TI announces DATA-GAGE*

Remote Liquid Level Measurement System

The DATA-GAGE is the direct product of Texas Instruments working closely with the engineers of a leading oil company. The result is the first transistorized automatic tank gauge that gives you *triple-check* reliability, dependable Power Float accuracy to 1/16 inch, low maintenance, operational simplicity, and 100-tank capacity in ONE LOW COST SYSTEM!

Eliminates Costly Errors—DATA-GAGE does not depend on alertness of operator to catch errors. System *automatically triple-checks* itself for accuracy before any data is displayed: 1. Operational check of Power Float; 2. Identification of tank connection; 3. Telemetering check for correctness and completeness of data.

Dependable Accuracy Under All Conditions—1/16 inch accuracy at depths of zero to 64 feet. No need to recalibrate over a wide range of liquids, temperatures and specific gravities. DATA-GAGE is the *only* system to give reliable readings during blending turbulence.

Low Initial and Long-range Cost—DATA-GAGE is a complete measurement system requiring no expensive extras. No special transmission system or conduits are required at installation—often existing ground level gauge connections and pipes can be utilized. Transistors are used instead of short-lived vacuum tubes. Easy access and quick-disconnect parts in all units make this the easiest to service of all systems.

Operational Simplicity—operator simply dials tank number and awaits data to be displayed seconds later on the exclusive DataFLASH reading panel. He need not make comparative readings to determine errors—DATA-GAGE automatically checks itself.

Power Float Reliability—the mechanical surface finder is a moving rather than static float, registers the instant surface tension is broken. No possibility of tilting, locking or sticking and giving an erroneous reading.

Proved Telemetering—true digital system employs digital code in binary decimal form. Means of transmission is a completely redundant (code group and its complement are transmitted), three-state code, the reliability of which has been thoroughly proved in transatlantic telegraphy.

Utmost Safety Precautions—field units are plug-in type which may be removed to safe area for servicing. No electric wires enter the tank. Explosion-proof housings are available on all field units.

For complete detailed information on the modern DATA-GAGE system, write for Bulletin No. M-601.

TEXAS INSTRUMENTS INCORPORATED

INDUSTRIAL INSTRUMENTATION DIVISION

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*TRADEMARK REGISTRATION APPLIED FOR.

Reportedly the World's Biggest Platforming Heaters are being erected by Procon Incorporated at Gulf Oil Company's Philadelphia refinery, where 2 26,000 B/SD units are under construction. More than 100 ft long, the outsized heater installations will each handle 2 intermediate stages. The platforming units are the second and third to be built at the refinery, and are expected to go onstream early next year.

JONES & LAUGHLIN SUPPLY DIVIsion has announced the establishment of a new product department in the firm's general office at Tulsa. The department will be known as the subsurface equipment section. Henry Franks, formerly special representative, has been appointed as manager of this section. Products to be handled by the department are: sucker rods, all subsurface pumps or working barrels, floating equipment, well heads and Christmas trees.

ALL REPAIR PARTS SALES AND service functions for the meter products division, A. O. Smith Corporation, Los Angeles, are now being handled by the corporation's 5 product service division branches located in key cities across the nation. Customers who have been contacting the sales offices and factories for functions should in the future deal directly with the nearest product service division branch.

UNITED STATES RUBBER COMpany plans to spend a minimum of 120 million dollars on research and development over the next 5 years. This spending for research and development is part of a 5-year program of expanded effort at the research center and at the company's laboratories at 22 locations, including plants in this country and Canada and plantations in the Far East.

ANNOUNCEMENT IS MADE OF THE purchase by Houston Oil Field Material Company, Inc., of all the capital stock of Oil Equipment, Ltd., a Canadian organization in the oilwell supply business in the oil fields of Western Canada.

CREATION OF A NEW PRODUCT research and development division of The J. B. Beaird Company, Inc., has been announced following the first meeting of Beaird directors in Shreveport. The new division will seek to develop new products for manufacture by Beaird, as well as uncover new and extended markets for present products.

THE WESTERN COMPANY, WELL servicing concern with headquarters in Midland, Texas, has consolidated its operations and sales departments. The consolidation resulted in the forming of Oklahoma and Midland divisions, with respective headquarters in Oklahoma City and Midland.

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The New 82-V vacuum pumping unit "with dry sight feed," an exclusive Manzel development will end your liquid sight feed problems. Install them on any existing Manzel lubricator. Now — more accurate than ever . . . it will pay you to get complete detailed information on this dependable, field-proven Manzel unit.
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Cross section shows structural superiority of Aeromaster's new, extruded aluminum-alloy blades in diameters from 9′ to 22′.

NEW! EXTRUDED ALUMINUM Blades on AEROMASTER* fans only

AEROMASTER'S new, extruded aluminum blades combine in one design the advantages of a light weight metal, a hollow structure and the superior strength of wrought metal . . . Silicon-magnesium aluminum alloys resist corrosion. Their fine grain structure, high tensile strength and increased endurance eliminate danger from wear, vibration, and metal fatigue . . . true airfoil blade sections assure maximum air delivery . . . adjustable blade pitch angle permits decrease of fan load to an accurate minimum horsepower requirement.

The AEROMASTER fan is easily assembled *in the tower*. No special handling equipment is necessary. AEROMASTER fans cost less to install, less to operate, less to maintain!

For more details write to KOPPERS COMPANY, INC., Aeromaster Fan Dept., 6707 Scott Street, Baltimore 3, Maryland.

KOPPERS

Aeromaster Fans

Engineered Products Sold with *Service*

*Koppers Trademark

Trade Parade

Planning Engineers shuffle ¼-inch scale models of multi-ton forging presses and plot new production flow lines in anticipation of plant expansion by Tube Turns division of National Cylinder Gas Company. The firm will expand manufacturing area 40 percent by a $400,000 conversion of existing buildings on property purchased last year for $2,000,000, making room for new product lines as well as expansion of welding fittings and custom forgings departments.

ROCKWELL MANUFACTURING Company's current expansion program in its western Pennsylvania plants has been completed, and remodernization of a portion of its Pittsburgh headquarters is nearly finished. More than 50,000 sq ft of manufacturing space, in addition to a new gas meter laboratory, have been added to the DuBois, Pa., gas meter plant. Approximately 27,000 sq ft, including new engineering facilities have been added to the Uniontown, Pa., water meter plant. Also, Rockwell has acquired Ilo-Werke, G. m. b. H., a leading West German manufacturer of 2-cycle, air-cooled diesel and gasoline engines.

HEWITT-ROBINS, INC. HAS ANnounced that it will move next year to a new regional office and warehouse. The new building will be 1-story high. It will contain 30,000 sq ft of office and warehouse space.

AMERICAN IRON HOLDS SPECIAL Sales Meeting. American Iron & Machine Works Company held a special sales meeting in Oklahoma City, attended by 40 of their district managers and special representatives, for the presentation of new product information. Films, slides and charts were used by American Iron engineering department in presenting data on the products soon to be announced to the industry.

THE AMERICAN BOSCH ARMA Corporation has purchased Hydramotive, Inc., of Cleveland, Ohio. Hydramotive has developed a hydraulic starter known as the Hydrotor which has a highly appropriate place in the product line of the American Bosch Division.

THE FLUOR CORPORATION, LTD., has established a wholly-owned subsidiary in London, England, to take advantage of the rapid expansion of the petroleum and petrochemical industries in the Sterling areas and Free Europe.

TEXAS INSTRUMENTS LIMITED, Bedford, England, a wholly-owned subsidiary of Texas Instruments Incorporated, of Dallas, Texas, formally opened its new plant for the manufacture of transistors and other semiconductor devices and their marketing throughout the sterling area countries.

PEOPLE

Andrew W. Rose has been elected vice president and assistant to the president of the Byron Jackson Division of Borg-Warner Corporation. **James N. Gregory** has been elected vice president and general manager of the Petro-Mechanics Research Division of Borg-Warner Corporation, and **W. C. Brooks** has been named to head Byron Jackson Tools' new industrial rubber sales department.

A. W. Rose

J. N. Gregory

Several personnel promotions and changes have been made by the Oil Center Tool Company. **C. T. Jones** has been named assistant sales manager with headquarters in Houston. **Jack Norton** has been promoted to manager of export sales, also with headquarters in Houston. Replacing Norton is **A. M. Taylor.** New manager of the West Texas-New Mexico District is **A. C. West, Jr. Jim Humphries** has been transferred from Houston to handle city sales in the North Texas area with offices in Dallas.

James R. Britt, formerly manager of the chemical plants division of Procon Incorporated, has taken over as general manager of Procon (Great Britain) Limited with headquarters in London. **Charles B. Robbins,** Procon (Great Britain) general manager since 1952, has returned to Procon's home office here as assistant to the president.

McNamar Boiler and Tank Company, Tulsa, has announced the appointment of **Charles Gay** as vice president in charge of manufacturing. Before his appointment with McNamar, Gay was affiliated with Vulcan Steel Tank Corporation. **Robert B. Allen** has been appointed as vice president of the firm. Allen was affiliated with Gas Equipment Company prior to his appointment with McNamar.

Charles Gay

R. B. Allen

John N. Cooper has been appointed branch manager of Clark Bros.'s new branch office and warehouse in New Orleans, Louisiana. To his new position Cooper brings a wide knowledge of all phases of compressor, engine and gas turbine applications.

Clean Living... EASTERN STYLE

People along the Eastern seaboard, from the Piedmont to the Bronx, are mighty pleased with the natural gas they're getting from Transco-served utilities. They're calling on us to deliver more every year, offering the steady demand of the most people with the greatest need for clean fuel.

HELPING DEVELOP A MARKET FOR TEXAS-LOUISIANA NATURAL GAS

TRANSCONTINENTAL GAS PIPE LINE CORPORATION

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

RECTORSEAL

now offers a choice of

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great sealing compounds

RECTORSEAL NO. 2

is fast drying — soft setting.

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is slow drying — soft setting.

You can use either Rectorseal No. 2 or No. 5, and be sure of leakproof connections. Both have the same positive sealing quality — the same smooth-flowing easy-to-use application that means speed and economy in use.

FREE SAMPLE is available on request. Write today for yours.

RECTORSEAL DEPT. H
2215 COMMERCE STREET
HOUSTON 2, TEXAS

RECTORSEAL
THE POSITIVE LEAK PREVENTER

Trade Parade

Edwin T. Goree was promoted to assistant general sales manager of Bucyrus-Erie Company. In 1955 he came to Bucyrus-Erie's south Milwaukee office as assistant sales manager, excavator distributors.

E. T. Goree

C. C. Simmons

C. C. Simmons, Franks employee since 1934, has been named as director of sales and service for both Franks Division, Cabot Shops, Inc., and of the Cabot Shops, Inc., according to an announcement by **R. A. Baker,** vice-president and general manager of Cabot and Franks. Simmons has moved to Pampa and assumed his duties in charge of sales for Franks well servicing units and drilling rigs and Cabot pumping units. He has served in almost every capacity in the Franks organization, including the field, service department, shop and in administrative positions.

The appointment of **Edward E. Parker** as general manager of Cameron Iron Works, Ltd., Leeds, England, has been announced. Parker has been in England since 1951 serving first with an affiliated company, British Oilfield Equipment Company, and for the last 2 years as factory manager of Cameron's own plant in England.

Continental-Emsco Company has appointed seven division merchandise managers:

H. C. Fox, headquartering at Shreveport, Louisiana; **G. L. Parks,** stationed at Casper, Wyoming; **R. E. Schiebel,** headquartered at Houston, Texas; **Harry Hobbs, Jr.,** working out of Oklahoma City; **P. J. Allen,** Drayton Valley, Alberta, Canada; **Ralph Dodworth** of Los Angeles, California and **Wendell True,** Abilene, Texas.

M. C. (Mac) Bolin has been appointed vice president of the gas compressor and gas products division of McNamar Boiler and Tank Company. Bolin joined McNamar in 1946 as a salesman, was made sales manager and in 1953 was appointed manager of the gas compressor division, the position which he held prior to his recent appointment as vice-president.

M. C. Bolin

C. H. Vaupel

Carl H. Vaupel was named vice president and general manager of the Aldrich Pump Company. Vaupel succeeds **G. Donald Ruhe** who is retiring.

Purchasing agents agree: when you need fast delivery, you order Worthington QD (Quick Detachable) sheaves — the original two-piece design. MV 7.10

WORTHINGTON CORPORATION, Oil City, Pennsylvania

Trade Parade

Appointment of **E. J. Byrne** as petroleum industry manager for the industrial division of Minneapolis-Honeywell has been announced. Byrne joined Honeywell in 1947 as an industrial instruments salesman in the Houston office.

Edward E. (Mike) Temple is the new product development engineer and **Jack Larkin** has joined the engineering department of the Larkin Packer Company. Temple will make his headquarters in Houston, and Larkin has been assigned to the general offices in Waxahachie, Texas.

Baroid Division National Lead Company has announced the appointment of **Kemp S. Lewis** as administrative assistant to the manager, drilling mud department. Lewis has been with Baroid since 1939. **Forest B. Vick** has been appointed chief drilling mud engineer. Replacing Vick as assistant chief drilling mud engineer is **Norman K. Tschirley. Kenneth D. Tanner** has been appointed area engineer, Louisiana Gulf Coast, replacing Tschirley.

K. S. Lewis

J. H. Wyres

James H. Wyres, former district manager for West Coast sales, has been named sales manager of the W-S Fittings Division of the H. K. Porter Company, Inc. Wyres is a veteran of 17 years experience with the W-S Fittings Division.

Statement Required by the Act of August 24, 1912, as Amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) Showing the Ownership, Management, and Circulation of

THE PETROLEUM ENGINEER

Published monthly, semi-monthly in July, at Dallas, Texas, for October 1, 1957.

1. The names and addresses of the publisher, editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Company, 800 Davis Bldg., Dallas, Texas.

Editor-in-Chief: F. H. Love, 800 Davis Bldg., Dallas, Texas.

Business Manager: Joe B. Woods, 800 Davis Bldg., Dallas, Texas.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)

American Security Life Insurance Company, Marshall, Texas.

Fidelity National Life Insurance Company, 403 South Akard, Dallas, Texas.

Investors Life Insurance Company, 403 South Akard, Dallas, Texas.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

Reserve Life Insurance Company, 403 South Akard, Dallas, Texas.

K. C. Sclater, 6365 Camino de la Costa, La Jolla, California.

4. Paragraph 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

Joe B. Woods, Business Manager.

Sworn to and subscribed before me this 30th day of September, 1957.

(Seal) Lillian H. Johnston
Notary Public, Dallas County.
(My commission expires June 1, 1959.)

The hotel with MORE

With every passing year, the most important individuals and groups in the insurance business find the Edgewater Beach has more — so much more — to offer and to enjoy.

You can mix business and pleasure in the Country Club atmosphere of the Edgewater Beach. Putting greens, tennis courts, luxurious Cabana Club and pool, and areas of shaded walks and gardens.

And you'll find dining to suit every taste. The Polynesian Village, Charterhouse, Yacht Club and Rib Room.

Yes, the Edgewater Beach offers you more for your own enjoyment, for parties, meetings or conventions for groups 10 to 1000.

THE Edgewater Beach HOTEL

NEW YORK Hotel Roosevelt · WASHINGTON The Mayflower · CLEVELAND Hotel Cleveland
CHICAGO Edgewater Beach Hotel · BOSTON Somerset Hotel

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PRESSURE CONTROLS

FOR SPECIAL APPLICATIONS

Low Operating Pressure—High Over-Range Protection

● **EXAMPLE APPLICATIONS**

1. Provide low suction protection on pumps where suction pressure may go to very high line pressures (up to 2,500 psi.)

2. As an interlock to prevent a door to a pressure chamber from being opened until the pressure has dropped to atmospheric pressure (1" H_2O) with over-range protection to 600 psi.

● **TWO SERIES AVAILABLE**

Series DA-900: Bourdon tube operated. Over-range protection to 2,500 psi. Operating ranges 0-60 psi; 0-100 psi; 0-150 psi; 0-300 psi.

Series CP: Diaphragm operated. Over-range protection to 600 psi. Operating ranges 1"-60" pressure or 1"-60" vacuum.

Both types available in various style cases.

SEND IN YOUR CONTROL PROBLEM OR WRITE FOR BULLETINS CA-21 & CA-1P

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

H. Whitely

J. F. Wright

Harold Whitely has been appointed Permian Basin area sales manager for Baash-Ross Tool Company, division of Joy Manufacturing Company.

Joseph F. Wright was appointed senior engineer in charge of engineering test facilities for Cameron Iron Works, Inc. of Houston. Wright joined Cameron in August 1955, as an application engineer and until this appointment has been in charge of field testing Cameron's valve products.

T. C. Ficken has been appointed sales manager of the Southeastern United States for the meter and service station pump divisions of the A. O. Smith Corporation.

Richard T. Biedler has been appointed advertising manager for Electronics and Instrumentation Division of Baldwin-Lima-Hamilton Corporation.

John Robell has joined the sales engineering staff of Badger Manufacturing Co. He is recognized as an authority in the development of process improvements for synthetic ammonia, methanol, synthesis gas, hydrazine, urea and other chemicals.

FISHING AND RENTAL TOOL SERVICE
. . . ANYWHERE . . . ANYTIME!
Phone or write today!
use ACME'S
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SAND PUMPS AND
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Competent Operators "On Call"
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Wichita Falls Fishing Tool Co.
Ph. 3-1437

Charles P. Siess Jr. has been appointed assistant to **James E. Stockton Jr.**, general sales manager for the Tretolite Company, division of Petrolite Corporation. **John Clote,** formerly field engineer for the Tretolite Company, is now assistant advertising manager of Petrolite Corporation.

Robert A. Brown has been promoted to the newly created position of vice president, general sales manager of Borg-Warner International Corporation.

Continental-Emsco Company announced the following changes in D + B specialist personnel: **Andrew J. Artzer,** D + B specialist to be stationed at Kimball, Nebraska; **Thomas A. Mann,** formerly located in Ardmore, Oklahoma, to Continental-Emsco's Tulsa division office; **David F. Barton,** previously of Midland, Texas, to Ardmore, Oklahoma; **Ernest C. Shoemate,** newly appointed D+B specialist to headquarter in Drumright, Oklahoma; **Don A. Davis,** appointed D + B specialist for Houston, Texas branch store; **Donald M. Thorwart,** located in Newcastle, Wyoming, formerly located in Kimball, Nebraska.

OTM Corporation, of Houston, Texas, has announced the appointment of **A. E. Arrington** as new district manager covering the Rocky Mountain territory with headquarters in Denver, Colorado.

The retirement of **John F. Maher** from active management of Oil Center Tool Company, Houston, Texas, has been announced. Maher's successor as president is **W. Al Wolff.**

The promotion of **Earl P. Martin** to assistant branch manager, Houston office, has been announced by The Cooper-Bessemer Corporation. In his new position, Martin will assist directly in the management of the Houston office and warehouse facilities.

E. P. Martin

G. K. Sutton

The appointment of **George K. Sutton,** George K. Sutton Company of Crowley, Louisiana, as manufacturer's representative for Win-Well MultiPort Valves, Win-Well Manufacturing Company of Los Angeles, has been announced. Sutton will cover the Southern Louisiana, Gulf Coast, Mississippi and Alabama areas.

Newly assigned to western sales posts for Allis-Chalmers industries group are: **James C. Barnett,** Dallas district office; **Hugh T. Coplen,** Phoenix district office; **Dale Stephenson,** power plant equipment representative in the Southwest region, which has its headquarters in Dallas, and **Theodore E. Meyers,** Portland district.

Donald K. Ballman, general sales manager of The Dow Chemical Company since 1949, has been promoted to the position of director of sales. He succeeds **Donald Williams** who recently was appointed director of corporate relations. **William R. Dixon** is now general sales manager.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Every Step of the way

THE MOST COMPLETE GUARANTEE IN THE FLANGE & FITTING INDUSTRY

Take off and go fishing! — Your OTM flanges guarantee you trouble-free performance — free from worry about flange failure. Specify OTM Blue Ribbon and relax!

A Symbol of Quality and Service — EST. 1919

Your BLUE RIBBON GUARANTEE

Each OTM product is guaranteed to be free from manufacturing defects. If failure occurs within one year after shipment, any OTM product will be replaced without charge when the following conditions have been met:

Provided it has been used as recommended and within A.S.A. and A.G.A. specifications and in accordance with recognized practices.

When the product is to be welded, provided it has been welded in accordance with recognized practices and within such Standards as A.S.M.E. and A.W.S. Codes.

Provided it has not been worn out due to severe operating service, such as is encountered under extremely corrosive, abrasive or acid conditions which the steel was not made to withstand.

OTM Corporation will pay all transportation charges and any necessary expense incurred to remove and replace any OTM product proved to be defective.

This is the broadest and most specific guarantee in the industry. You are CERTAIN of the superior performance of BLUE RIBBON PRODUCTS!

If you believe any OTM product to be defective, regardless of how minor the problem may be, call Mr. Kenneth H. Bradshaw collect (person to person) before making any final decision.

A Symbol of Quality and Service — EST. 1919

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Your New Sealing Problem May be an Old One to Us . . .

FREE ENGINEERING COUNSEL . . . We invite you to submit details on your sealing needs.

FOR 40 YEARS Durametallic has built up an extensive Service Record File. It covers answers to hundreds of specific sealing problems. In all probability we have the answer to your sealing problem in this "success" file.

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Drilling superintendents agree: for fast delivery you can't beat Worthington QD (Quick Detachable) sheaves — the original two-piece design. MV.7.2

WORTHINGTON CORPORATION, Oil City, Pennsylvania

Meetings

Nov. 4-7—**AIME, Institute of Metals Division,** Morrison Hotel, Chicago.

Nov. 4-8—**American Society for Metals,** 39th metal show, International Amphitheatre, Chicago, Illinois.

Nov. 5-6—**Natural Gas Pipe Line Institute,** sponsored by University of Kansas and Southwest Kansas Petroleum Industry, Randall's Cafeteria, Liberal, Kansas.

Nov. 6-8—**Society of Automotive Engineers,** national fuels and lubricants meeting, Hotel Statler, Cleveland, Ohio.

Nov. 6-8—**Gulf Coast Association of Geological Societies,** 7th annual convention, Roosevelt Hotel, New Orleans, Louisiana.

Nov. 7-8—**AAPG, SEG, and SEPM,** Pacific Sections, Ambassador Hotel, Los Angeles, California.

Nov. 10-14—**Society of Exploration Geophysicists,** national convention, Statler-Hilton Hotel, Dallas, Texas.

Nov. 11—**API, OIC,** Steering Committee meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 11-13—**Steel Founders' Society of America,** 12th Technical and Operating Conference, Carter Hotel, Cleveland, Ohio.

Nov. 11-14—**API,** 37th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 11-14—**Society of Exploration Geophysicists,** 27th annual meeting, Statler Hilton Hotel, Dallas, Texas.

Nov. 12-13—**API Board of Directors** meeting, Conrad Hilton Hotel, Chicago, Illinois.

Nov. 12-14—**National Association of Corrosion Engineers,** Northeast region, fall meeting, Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

Nov. 13-14—**Air Pollution Conference,** co-sponsored by Armour Research Foundation and Midwestern Air Pollution Prevention Association, Loop Hotel, Chicago, Illinois.

Nov. 13-16—**National Association of Corrosion Engineers,** Miami section meeting, Key Biscayne, Florida.

Nov. 20-21—**Santa Barbara Coastal Area,** oil industry safety conference, Hotel Miramar, Santa Barbara, California.

Nov. 22—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 1-6—**American Society of Mechanical Engineers,** annual meeting, Statler Hotel, New York City.

Dec. 2-6—**26th Exposition of Chemical Industries,** New York Coliseum, New York City.

Dec. 3-4—**Petroleum Packaging Committee,** quarterly meeting, Hotel Washington, Washington, D. C.

Dec. 4-6—**AIME, Electric Furnace Steel Conference,** Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

Dec. 5-6—**API Oil Information Committee** meeting, Biltmore Hotel, New York City.

1958

Feb. 2-7—**ASTM Committee D-2** meeting, Rice Hotel, Houston, Texas.

Continued on Page E-42

follow the factory's lead . . . get better service from your

Waukesha MOTOR

GAS ENGINES

STITT

NEW TRIPLE IGNITOR

SPARK PLUGS

Waukesha is now factory-installing STITT New Triple Ignitor Spark Plugs in all gas engines . . . STITTS cost a little more—save hundreds of dollars per engine per year because they last longer, cut downtime substantially, increase magneto life, require less service. Also, factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

Write today for new Application Chart—matches spark plug recommendations to engine service —you'll get better plug performance.

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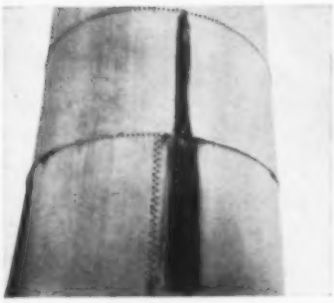
STITT IGNITION CO

COLUMBUS 1, OHIO

STITT MAKES HEAVY-DUTY, INDUSTRIAL-TYPE PLUGS!

Stop LEAKAGE with Epi-SEAL®

New epoxy resin compound seals weeping rivets and welded seams of tanks, tank trucks, transports and rail tank cars



Before

Applying Epi-SEAL SEAM SEALER

After

Now — quickly, safely and economically — you can permanently seal leaks in tanks and piping . . . stop corrosion before it has a chance to cause extensive damage. No flame, no heat required.

The solution? . . . Epi-SEAL SEAM SEALER, an epoxy resin compound with fibrous reinforcer. This newly developed, highly superior sealant is impervious to oil, water, most acid and chemical solutions. Easily applied, it hardens into a tenacious, bottle-tight bond which will contract and expand with the steel to which it is applied.

Epi-SEAL SEAM SEALER comes in a complete unit. It is simple to use; clean the area around the leak, mix the resin and activator together and stir in the fibrous reinforcer. Apply with a paint brush to the leaking area.

Epi-SEAL offers tremendous advantages to the oil industry. Write or phone us for name of nearest dealer or specific technical advice.

Attractive distributor franchises still available in some areas. Write for details.

BONDED PRODUCTS, INC.

538 Freeman Street

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ARMSTRONG BROS.

Better PIPE TOOLS

PIPE VISES

"ARMSTRONG BROS." Pipe Vises. Standard Hinged Vises have drop forged (unbreakable) hooks, and replaceable tool steel jaws. Smaller vises have 1-piece jaw which prevents kinking of small or thin wall pipe. T-Handles have oval ends that will not pinch hands. The Open Side Vise mounts on a bench, truck, or with special chain attachment on any post or tree. The Chain Vise has drop forged base, jaws and handle. Chains are proof-tested. Patented 1-piece jaw prevents damage to small pipe, thin wall conduit or tubing.

Write for Pipe Tool Circular

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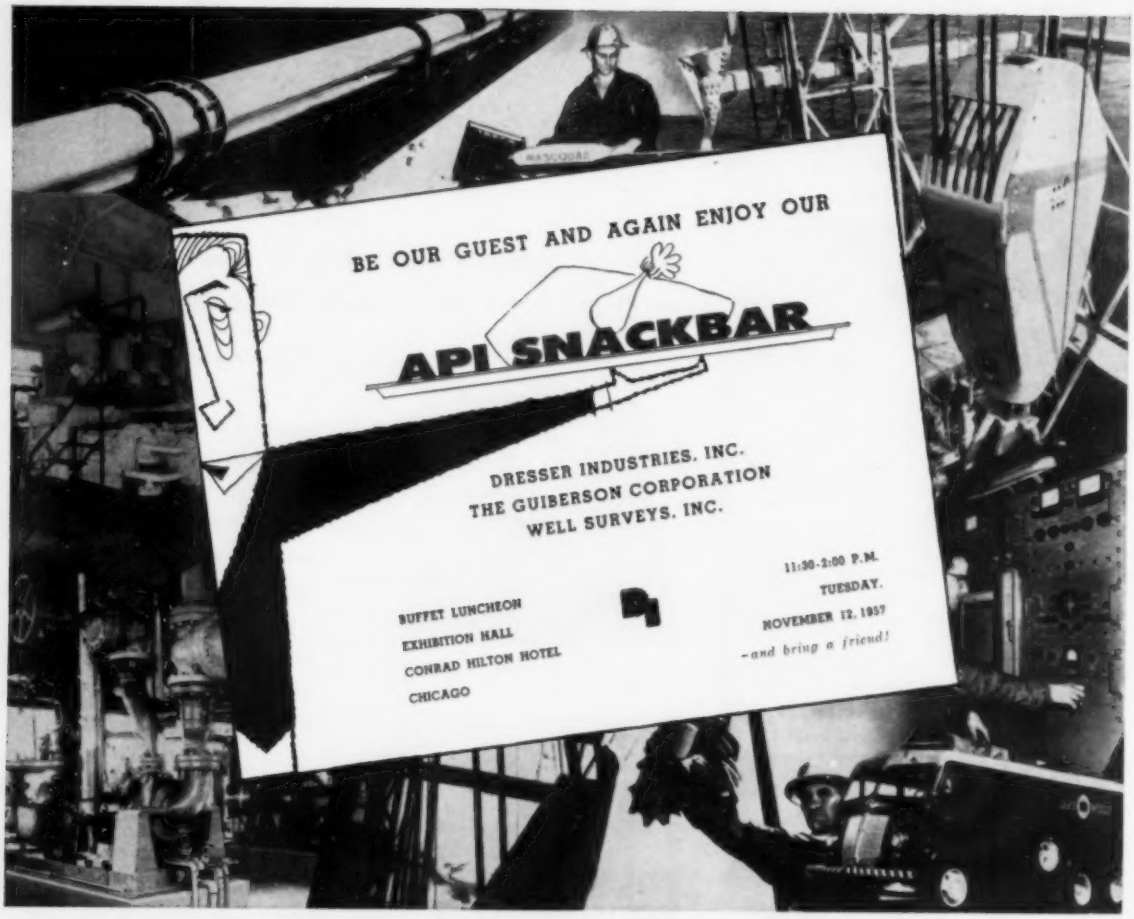

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AMERICAN PETROLEUM INSTITUTE

37TH
ANNUAL MEETING

Conrad Hilton Hotel
Palmer House
Chicago, Illinois
November 11-14, 1957

Dresser pays tribute to the members of the American Petroleum Institute for their many contributions to the progress of our vital oil and gas industries.

THE DRESSER INDUSTRIAL TEAM SERVES THE GROWING OIL

the Dresser Badges of Merit plus+

CLARK

CLARK BROS. CO., Olean, New York —Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors—gas, steam, electric and diesel driven.

DRESSER IDECO

DRESSER-IDECO COMPANY, Columbus, Ohio—Radio and television broadcasting towers, steel buildings, aircraft hangars, electric power substations.

DRESSER MANUFACTURING DIVISION

DRESSER MANUFACTURING DIVISION, Bradford, Pa.—Pipe line couplings, pipe repair sleeves and clamps, weldments, forgings, welding fittings, flanges, rings.

GUIBERSON "We'll Be Better Than Sorry"

THE GUIBERSON CORPORATION, Dallas, Tex.—Swabs, packers, anchors, workover equipment—drilling heads, blowout preventers, tubing blocks, hooks, swivels, kellys, savers, unions. Gas lift equipment. Molded rubber products.

IDECO

IDECO, Dallas, Tex.—Hydrair* and Power Rigs; Full-View* Masts; substructures; single, dual and Drive-In Rambler Rigs; blocks, swivels, rotaries; mud pumps; petroleum equipment and supplies.

LANE WELLS

LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging, Koneshot* perforating and bullet perforating, packers and bridging plugs.

Magcobar.

MAGNET COVE BARIUM CORP., Houston, Tex.—Magcobar* and Magcogel* drilling muds and other specialized oil well drilling fluids and chemicals.

PACIFIC

PACIFIC PUMPS, INC., Huntington Park, Calif.—Centrifugal pumps for refineries, power stations, pipelines, and chemical plants; plunger pumps for oilwells.

ROOTS-CONNERSVILLE SINCE 1854

ROOTS-CONNERSVILLE BLOWER DIVISION, Connersville, Ind.—Rotary positive blowers, gas pumps, centrifugal blowers, exhausters, vacuum pumps, and positive displacement meters.

Security

SECURITY ENGINEERING DIVISION, Dallas, Tex., Whittier, Calif.—Rock bits, reamer rock bits and hole openers; reamers, casing scrapers and Neo-Red rubber stabilizers.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO., Houston, Tex.—Seismograph systems and instruments—electronic, electro-mechanical. Computers—analog and digital; recording systems. Special transformers, reactors.

WELL SURVEYS

WELL SURVEYS, INC., Tulsa, Okla. —Nuclear and electronic research and development for the petroleum and other industries. Originators of radioactivity logging.

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put this DRESSER *plus+* team to work for you!

You receive a bonus of extra value whenever you are served by any one of the Dresser companies. *Men with imagination* provide the research, engineering, manufacturing and service applications for the particular specialties of each Dresser operating unit. All Dresser companies work together with their combined experience and facilities to form the world-wide Dresser industrial team. This inter-company teamwork offers a bonus in greater experience and technical knowledge—backed by the extensive Dresser facilities—in the customer's specific industry. This intangible but important factor is known the world over as the Dresser plus + . . . the mark of superior equipment and services for the oil, gas, chemical, electronic, and general industry.

Dresser's world-wide engineering experience in many industries plays a major role in the creation of new developments and improved technological methods. No other single company provides the same broad range of equipment and services. The Dresser plus + is a symbol for the superior quality of equipment and technical services which have become the standard of comparison in industries the world over!

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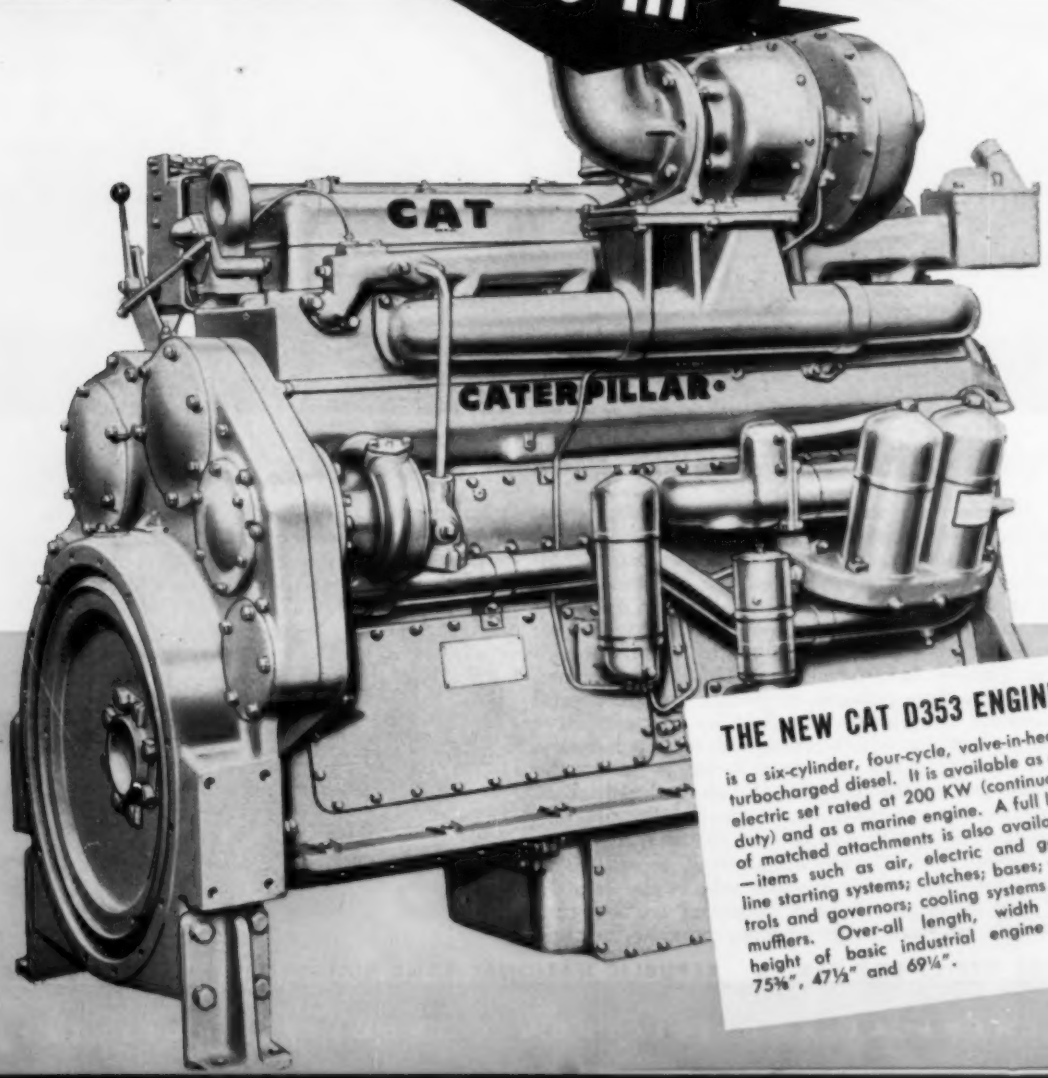
GAS, CHEMICAL AND ELECTRONIC INDUSTRIES — EVERYWHERE

Caterpillar announces in the world's most

The engine that delivered outstanding is now available as the D353 Industrial

D397 650 HP† | D375 430 HP† | **New D353 390 HP†** | D342 225 HP† | D339 140 HP†



THE NEW CAT D353 ENGINE

is a six-cylinder, four-cycle, valve-in-head turbocharged diesel. It is available as an electric set rated at 200 KW (continuous duty) and as a marine engine. A full line of matched attachments is also available —items such as air, electric and gasoline starting systems; clutches; bases; controls and governors; cooling systems and mufflers. Over-all length, width and height of basic industrial engine are: 75⅜", 47½" and 69¼".

another heavy-duty engine advanced line of diesels

performance in the famous D9 Tractor Engine, Electric Set and Marine Engine

D337	D326	D318 (SERIES G)	D315 (SERIES G)	D318	D315	D311
310 HP†	200 HP†	175 HP†	115 HP†	137 HP†	91 HP†	65 HP†

†Maximum output capacity

Adding to Caterpillar's line of modern heavy-duty engines, there's now the Turbocharged D353 rated at 390 HP (maximum output capacity). This engine, a prototype of the unit in the mighty D9 Tractor, is job-proved after thousands of hours of operation in the field!

Like all modern CAT* Diesels, the D353 incorporates in its design the advanced features developed by Caterpillar in a quarter century of diesel leadership. Compact and sturdy, it is built for the hard work. Its four-cycle design delivers the long, effective power stroke that puts power to more efficient use than other types of engines. Its turbocharger utilizes waste energy from the engine exhaust to increase over-all efficiency and economy. Its fuel system requires no adjustment. There are no cylinder ports to clean. And its exclusive Caterpillar single-orifice injection valves, combined with the precombustion chambers, permit the use of a wide range of fuels including premium diesel fuels as well as low-cost No. 2 furnace oil *without fouling*. All these and other features add up to performance that no unit in its power class can match.

With the addition of the D353 to the Caterpillar Engine line, you now have a wider choice than ever for your requirements. Engines are available up to 650 HP (maximum output capacity) and electric sets up to 350 KW (continuous duty). Either as original or replacement power, there's one among hundreds of different arrangements that exactly meets your needs. Leading manufacturers of machinery can supply these models in the equipment they build.

For complete information about the new D353 and other Cat Diesels, see your Caterpillar Dealer. Let him show you how diesel leadership based on a quarter century of experience can engineer the modern, heavy-duty diesels of tomorrow.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

Caterpillar "Firsts" in a Quarter Century of Diesel Leadership

- "Hi-Electro" hardened cylinder liners
- Chemically conditioned cylinder liners
- Stainless-steel piston protectors
- Aluminum alloy bearings
- Interchangeable, adjustment-free fuel injection equipment
- Capsule-type injection valves
- Service meters
- Superior lubricants (detergent oils)
- Notarized, certified power

AND MANY MORE!

Certified Power for Cat Diesel Engines

Through the years, Caterpillar Engines have earned a reputation for *honestly rated power*. Now Caterpillar backs this reputation with a *notarized certificate* covering the horsepower capabilities of each engine. Caterpillar is the first and only manufacturer to give you this assurance of capacity. You have a right to demand certified power when you invest in an engine. You get it when you buy from your Caterpillar Dealer!

W-S Forged Steel Fittings...

Standouts for Pump and Compressor Piping

Whether the fluid be water, steam, oil, gas or chemical solutions ... if they are being pumped at high pressure, W-S Forged Steel Fittings will protect your pump or compressor piping. They are designed and manufactured to provide maximum resistance to pressure, shock and vibration.

W-S Fittings are drop forged from high strength carbon steel bars and precision machined on modern automatic equipment. A new blue synthetic coating protects the fittings from rust in storage and in service.

Don't forget ... you can order your W-S Fittings in handy packaged quantities.

For detailed information on our complete line of screw-end and socket-welding forged steel fittings, write to W-S Fittings Division, H. K. Porter Company, Inc., P.O. Box 95, Roselle, N. J.

H. K. PORTER COMPANY, INC.

W-S FITTINGS DIVISION

Continued from Page E-36

Feb. 12-14—**API Division of Marketing,** marketing research committee, Biltmore Hotel, New York City.

Feb. 16-20—**AIME,** annual meeting, Hotel Statler and Hotel Sheraton-McAlpin, New York City.

Feb. 26-28—**API Division of Production,** Southern district meeting, Shamrock-Hilton Hotel, Houston, Texas.

Feb. 27-28—**API Division of Marketing,** lubrication committee meeting, Sheraton-Cadillac Hotel, Detroit, Michigan.

Mar. 3-4—**Society of Petroleum Engineers of AIME,** 4th annual joint meeting of Rocky Mountain petroleum sections, Cosmopolitan Hotel, Denver, Colorado.

Mar. 5-6—**Gas Conditioning,** short course, sponsored by the schools of petroleum and gas engineering, The University of Oklahoma, Norman, Oklahoma.

Mar. 12-14—**API Division of Production,** Southwestern district meeting, Hotel Texas, Fort Worth, Texas.

Mar. 14-18—**Greater New York Safety Council,** 28th annual safety convention and exposition, Hotel Statler, New York City.

Mar. 20-21—**New England Gas Association,** annual meeting, Hotel Statler, Boston, Massachusetts.

Mar. 20-21—**AIME, Petroleum Production and Reservoir Engineering** conference, Mid-Continent local section, Mayo Hotel, Tulsa, Oklahoma.

Mar. 24-26—**Midwest Gas Association** meeting, Broadmoor Hotel, Colorado Springs, Colorado.

Mar. 27-29—**AIME, Pacific Southwest conference,** St. Francis Hotel, San Francisco, California.

Mar. 31-April. 2—**API Division of Transportation,** annual pipeline conference, Jung Hotel, New Orleans, Louisiana.

Apr. 1-3—**Corrosion Control,** short course, sponsored by the Oklahoma City chapter of the National Association of Corrosion Engineers and the College of Engineering, University of Oklahoma, Norman, Oklahoma.

Apr. 9-11—**API Division of Production,** Mid-Continent district meeting, Biltmore Hotel, Oklahoma City, Oklahoma.

Apr. 14-16—**AIME Blast Furnace and Open Hearth conference,** Hotel Statler, Cleveland, Ohio.

Apr. 15—**Independent Oil Men's Association of New England,** annual meeting, Hotel Statler, Boston, Massachusetts.

Apr. 17-18—**Society of Petroleum Engineers of AIME,** Louisiana, Arkansas, East Texas and Mississippi petroleum sections, gas technology symposium, Shreveport, Louisiana.

Apr. 17-19—**AIME, Pacific Northwest Regional** conference, Spokane, Washington.

Apr. 27-29—**Independent Petroleum Association of America,** midyear meeting, Hotel Sherman, Chicago, Illinois.

Apr. 28-29—**Automatic Control in the Petroleum and Chemical Industries,** short course, sponsored by the School of Electrical Engineering, University of Oklahoma, Norman, Oklahoma.

Get More Pipeline Oil From Each Producing Well Use **Humble's Breaxit** Emulsion Breakers

At your request, a trained engineer will make on-the-lease tests of your emulsions and recommend the formula and amount of *Breaxit* oil-treating compounds you need to produce pipeline oil. This on-the-lease testing is an extra Humble service that is yours without cost or obligation.

Humble's *Breaxit* assists you in producing maximum recovery at lowest possible treating costs.

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HUMBLE OIL & REFINING COMPANY

Humble Oil & Refining Company
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For information on *Breaxit* in Illinois, Indiana and Kentucky, write or phone:

Mid-State Chemical Company, Inc.
Mt. Vernon, Illinois.

For information on *Breaxit* in Oklahoma and Kansas, write or phone:

Pet-Chem, Inc. Mayo Building
Tulsa, Oklahoma.

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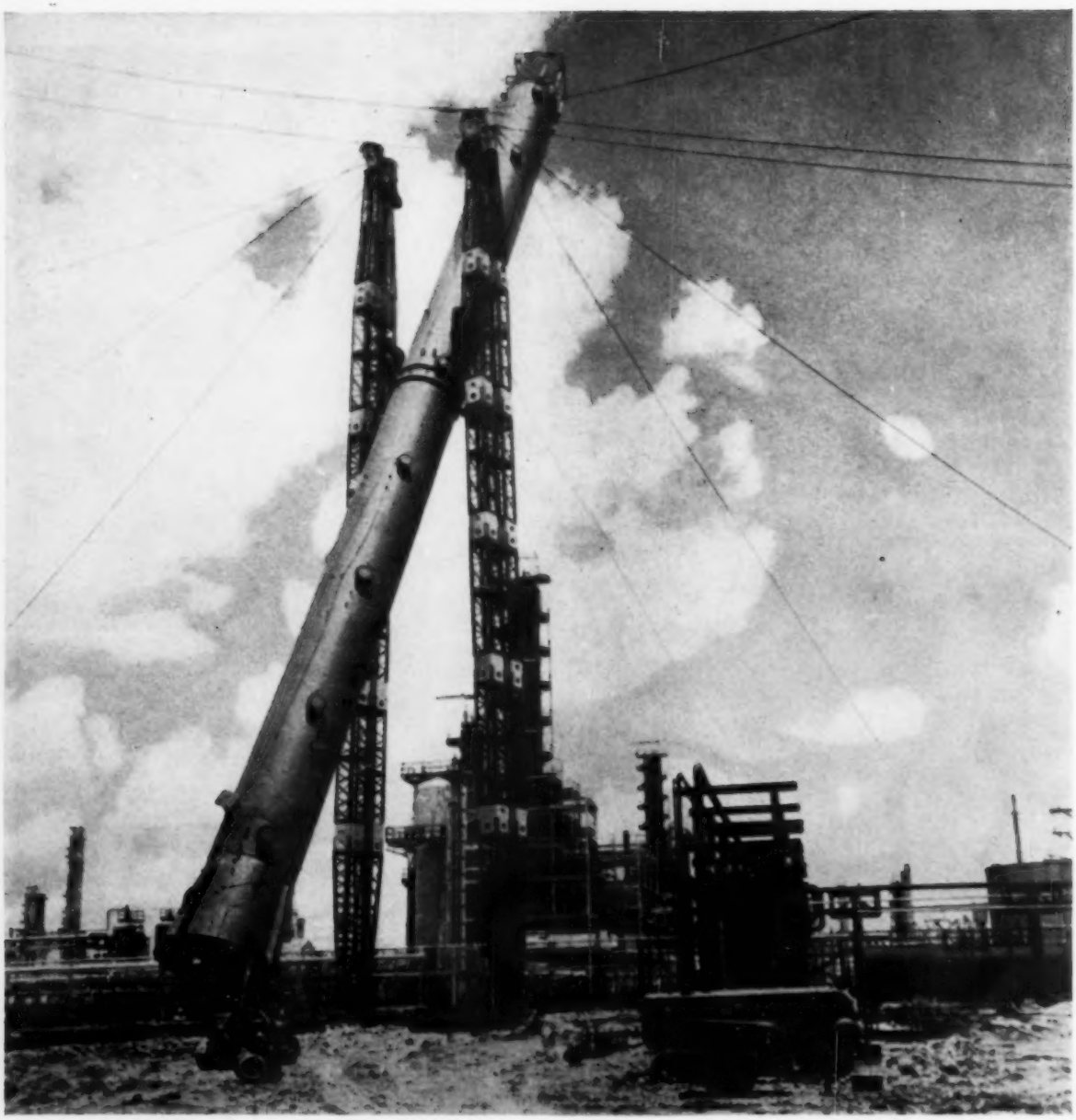


"Over the years, Jersey's expenditures for capital equipment, and costs relating to the search for and development of new oil reserves, have been very large. For the current year they will amount to $3 for each $2 of last year's profit."

M. J. Rathbone, President, Standard Oil Company (New Jersey)

Esso 75 YEARS

producing energy for an abundant life

STANDARD OIL COMPANY (NEW JERSEY)
AND AFFILIATED COMPANIES

TIGER BRAND ROTARY DRILLING LINE

. . . drills 51,641 feet of hole!

ONE Tiger Brand Wire Rope on the MacKellar Drilling Co. Rig No. 1, in the Oklahoma City Pool, drilled 12 wells for a total of 51,641 feet and 12,995 ton-miles. The rope used was 1750 feet of 1⅛" 6 x 19 Monitor Excellay with wire core.

J. P. MacKellar, owner and president, has used American Tiger Brand Wire Rope for many years and has always obtained outstanding service. By taking good care of the rope and following recommended cut-off practices, they have never had any trouble with Tiger Brand.

He says that Tiger Brand reels smoothly, has better lubrication, and to his knowledge is the best line they have ever used.

M. B. Lesher, driller, and Joe Blackman, Tiger Brand Specialist, measure the wear and find the rope is still in good condition.

AMERICAN STEEL & WIRE DIVISION

United States Steel, General Offices: Cleveland, Ohio

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

UNITED STATES STEEL

Roebling Royal Blue Wire Rope will **bend** and **bend** and **bend!**

What's more, Roebling Royal Blue is *stronger* than the strongest wire rope previously available. It will do more work and last longer on *your* job. Call your distributor or your nearest Roebling office for full information about Royal Blue, the really better wire rope. John A. Roebling's Sons Corporation, Trenton 2, New Jersey.

ROEBLING

Distributors, Branches and Warehouses Throughout the Country—Subsidiary of The Colorado Fuel and Iron Corporation

THE HAMMOND
DIALIFT

the only membrane type conservation tank

... with full-rated vapor and product capacity at all times

... with a membrane that cannot come in contact with product

... with vapor space that can be isolated for inspection and maintenance without taking tank out of service.

Principle of the Hammond Dialift

A—DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.

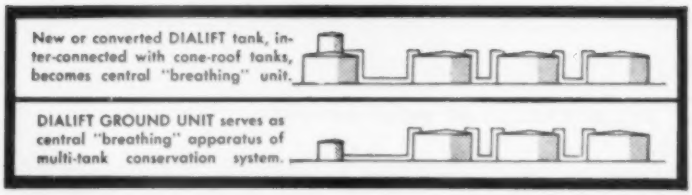
B—Vapor passes to and from tank and DIALIFT through simple elbow connection.

C—DIALIFT and tank have full-rated capacity.

D—Membrane can't come in contact with product.

E—DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

The most efficient and economical vapor conservation system for new or old tanks.


New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.
DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation:—Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a tank for vapor conservation for one or a number of tanks. The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

Write for dialift catalog 55DL

HAMMOND IRON WORKS

HAMONDTANK

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

LOW DOWN . . . The low, sleek lines of the modern American automobile are made possible by an ingenious engineering achievement called the hypoid gear. It drives the rear wheels, but because it meshes *below* their centers, engineers are able to reduce an automobile's height. Lubricating the hypoid gear posed a tough, complex problem . . . a problem eventually solved by the combined research skill of the automobile and petroleum industries. Texaco scientists pioneered in developing a rugged petroleum lubricant for this special purpose . . . another evidence of the cooperation and resourcefulness that has made Texaco research a valuable partner of modern industry in its march of progress.

TEXACO ***progress . . . at your service***

THE TEXAS COMPANY

NOT EVEN FIVE FEET OF PEAT BOG CAN HANG UP THE NO. 583

The Cat* No. 583 Pipelayer is not only the highest capacity pipelayer in history—but the most efficient. Mannix Ltd., Calgary, Alberta, has four of them in its 100% Caterpillar spread laying 110 miles of 30-inch gas line through southern British Columbia.

The line takes the No. 583s through 40 miles of reclaimed lake bottom, covered with heavy silt and peat bog four to six feet deep. But the No. 583 has a full 21-inch ground clearance, and the bog can't stop it.

These big yellow units were engineered to give you a full day's work no matter what the terrain. For this machine was designed after consulting spread superintendents, foremen, mechanics and operators throughout the industry. It incorporates all their ideas of the ideal pipelayer. As a result you have the first machine that is *all pipelayer*.

It has 130,000-lb. lifting capacity and its engine delivers 191 HP. There is a three-stage torque converter in the main drive and new hydraulically actuated counterweights. And the extra high bottom clearance of the counterweight pivot, coupled with the ability to retract the counterweights well over the tracks, means that the No. 583 can maneuver easily even while handling an extra heavy load on a narrow right of way.

Here's the safest, fastest, most efficient machine ever designed for pipelaying. Behind it stand an army of Caterpillar Dealers always ready to give you quick service with quality factory parts wherever the pipe takes you. Call your Caterpillar Dealer today. You name the date—and he will demonstrate on *your* job.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

WANTED—
THE HARD WORK

Now... at 1/10 the cost... a better

ANTI-STALLING ADDITIVE

GULF AGENT 178

... proved by over 25 billion miles of stall-free driving!

GULF AGENT 178 provides economic, effective anti-stalling performance in motor gasolines. At the same time, it affords corrosion protection at no extra cost.

Look at what GULF AGENT 178 offers you:

PROVED PERFORMANCE—GULF AGENT 178—long recognized as an outstanding corrosion inhibitor for all types of petroleum products—is now used by major refiners in modern volatile motor gasolines to eliminate stalling caused by carburetor icing . . . and its effectiveness for this use has been proved in service by over 25 billion miles of stall-free driving.

LOW COST—Small concentrations—15 to 25 pounds per thousand barrels—give anti-stalling protection at as low as 1/10 the cost of commonly used de-icing additives.

EASE OF USE—GULF AGENT 178 is readily soluble in all petroleum products—can be easily blended at temperatures ranging from minus 30 to plus 140° F. Also, it is insoluble in water and can be handled in conventional gasoline transfer systems with no danger of loss from water leaching.

MINIMUM STORAGE—The small concentrations required eliminate need for expensive additive storage.

EXTRA BENEFITS—Rust protection it provides lengthens life of distribution and storage facilities from refinery to customer.

Let us demonstrate GULF AGENT 178 in your gasoline!

Petrochemicals Department
GULF OIL CORPORATION
Gulf Building
Pittsburgh 30, Pennsylvania

QUALITY CHEMICALS *from* PETROLEUM

GULF®

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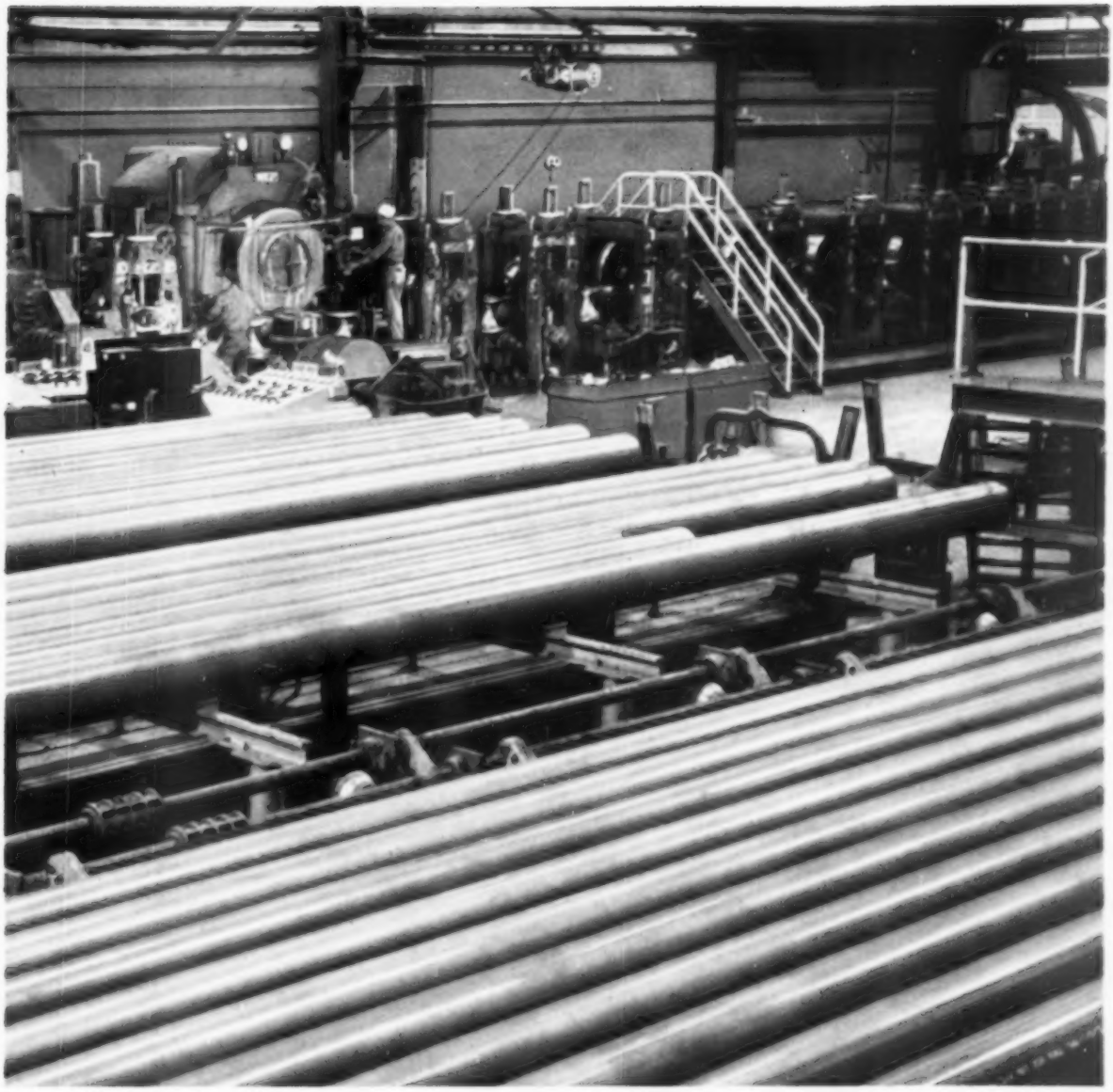

New J&L Electricweld Mill

produces line pipe from 6⅝" through 12¾" O.D.

Jones & Laughlin's new high speed Electricweld pipe mill is producing, in time for your 1958 requirements, electric welded line pipe in sizes ranging from 6⅝" through 12¾" O.D. in lengths up to 60 feet.

This modern mill includes several "firsts" that assure high speed, continuous production of quality electric welded line pipe for the gas and petroleum industries.

Among innovations are the feeding of 2,300-volt electric current directly into the welding transformer, increasing speed of response and availability of power at the weld; electronic measurement of a pre-determined forging pressure assuring the quality of the weld; "Vacu-Blast" treatment of weld area to remove scale.

All pipe is carefully finished and tested to meet ASTM and API specifications. Investigate J&L's new Electricweld line pipe today. Get all the details by writing Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Pa.

J&L STEEL

Jones & Laughlin

...a great name in steel

relocate! isolate! tie-in! sections of 6" and 8" lines *under pressure!*

any of these operations can be performed in complete safety with Mueller® No. 3SW Line Stopper Equipment.* Continual flow of fluid may be maintained by using a built-in, or if preferred, a completely separate by-pass line.

Mueller welding or mechanical joint line stopper fittings are equipped with a completion plug incorporating an equalizing valve. This valve maintains equal pressure on both sides of the completion plug and assures easy insertion or extraction under pressure. An "O" ring seal on the completion plug prevents leakage of fluid.

NO. 3SW LINE STOPPING UNIT

Two H-17340 Steel Wedge Stopping Machines and one H-17346 Completion Machine make stop-off and plug the fittings.

WELDING FITTING

Available with 150, 300, 400 or 600 pound flanges for pressures to 1200 p.s.i. at 100° F. Sizes 6" and 8".

MECHANICAL JOINT FITTING

Used where welding is not desired on either steel or cast iron pipe. Pressures to 175 p.s.i. at 100° F. Sizes 6" and 8".

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Factories at Decatur, Chattanooga, Los Angeles. In Canada: Mueller Limited, Sarnia, Ontario

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DEPT/Exploration, Drilling, Production
Edwards Deep Test Stirs Interest
EXPLORATION
Outlook—First Step in Williston's Comeback
By John C. McCaslin
TEMPERATURE BARRIER BROKEN by Ginther, Warren & Ginther KILLAM WILDCAT at Pescadito Salt Dome

Huge Salt Dome Found
• Wildcat confirms Pescadito structure near Laredo as big dome. It extends great Southwest Texas salt basin 35 miles west and opens up exciting oil possibilities
PESCADITO SALT DOME
HOUSTONIANS' TEST IN WEBB SETS RECORD
Ginther, Warren & Ginther of Houston
Pescadito test looks good as . . .
Huge Salt Dome Yields Gas
LAREDO. — South Texas' biggest exploration news—the Pescadito dome—is getting hotter.
Ginther, Warren & Ginther's wildcat on the structure had a big gas flow on a test last week. The well made headlines 2 weeks ago when it proved the existence of the deep salt dome (OGJ, June 24, p. 105).
Indicated producing horizon is the Georgetown lime. The test lasted only 20 minutes before a joint of drill pipe collapsed. During that 20 minutes, the well flowed gas with a tubinghead pressure of 2,400 psi, against a ¼-in. choke. There was no measure of the volume nor of the fluids consent.
The hole will be resumed just as soon as the operator can condition the mud, get the pipe out, and get
were their cases. For that reason, Ginther, Warren & Ginther took average of the two readings—450° F.—as correct temperature at log depth of 14,552 ft.
The company had expected to drill as deep as 17,000 ft. to find the main objective, the Edwards. Previous wells on the Pescadito structure logged high temperature gradients and it appeared that bottom-hole temperature of the 1 Killam might reach 500° F. if it found the Edwards. Previously, Magnolia Petroleum Co. chalked up the highest temperature ever drilled—in West Ranch, Texas, field in 1955. There temperature reached 389° F.
Lime-treated muds common to

Ginther, Warren & Ginther's confirmation of the deep Pescadito salt dome at Laredo is the most exciting geological performance in Texas this year.

DMS® MUD USED

Low-sodium DMS surfactant mud gave trouble-free performance, despite a record bottomhole temperature of 460°F at 14,552 feet. This is even more remarkable since the mud was subjected to numerous gas kicks and contaminated by drilling more than 700 feet of solid salt in the bottom of the hole.

COST: Contrary to expectations, the low-sodium DMS surfactant mud used costs no more than an ordinary mud of equivalent weight.

SERVICE: Magcobar programmed and serviced this low-sodium DMS mud designed for high-temperature drilling. Magcobar is prepared to assist in planning trouble-free DMS surfactant muds for the deeper, hotter holes which will open new producing horizons.

Contact Magcobar, using this coupon, for the complete information bulletin on DMS surfactant muds.

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Please send me your DMS surfactant muds Bulletin.

Name..... Title.....

Company.....

Address.....

City..... State.....

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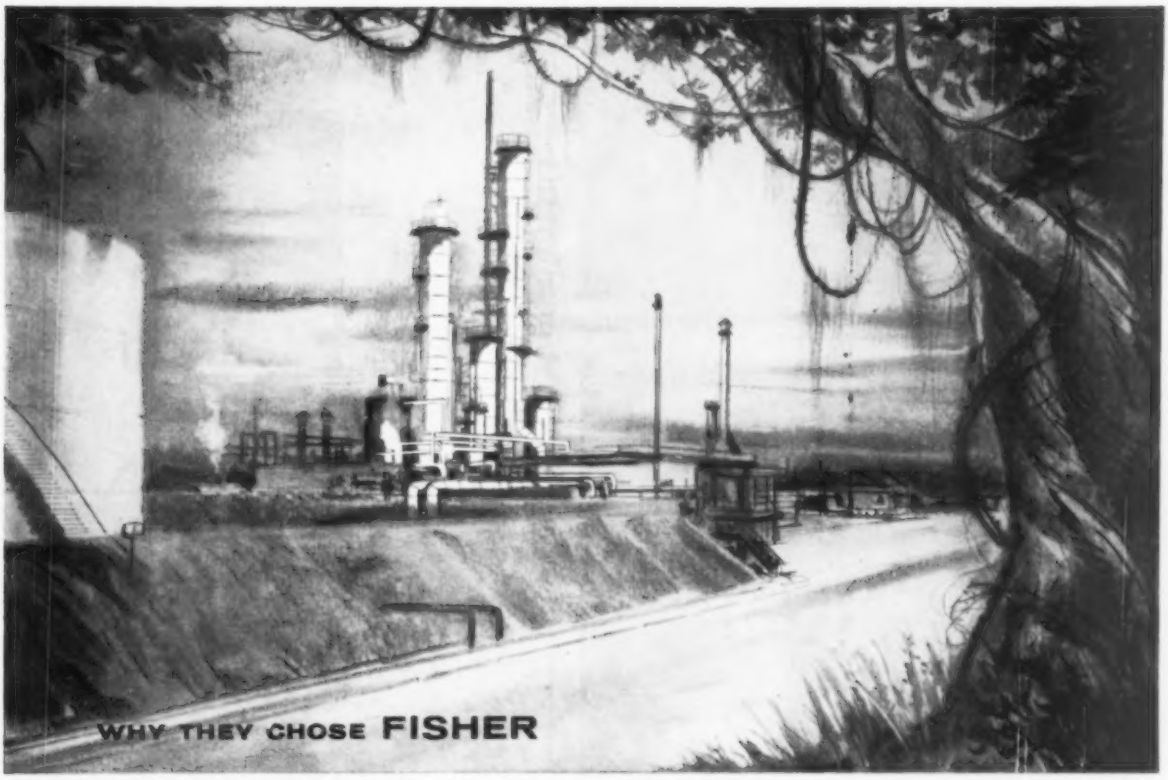
An oilman belongs at every table Pipeliners – in fact, *all* oilmen – help set the family table. Oil-based insecticides, weed killers, fertilizers, livestock dips and animal medicines help bring better fruits, vegetables and meats to market. You cook them with natural gas or electricity that oil fuels probably generated. Sometimes people who know little about oil talk loudly against our industry. That's when we oilmen should point out that at home, as elsewhere, oil serves people well. **SHELL OIL COMPANY**



A thousand miles up the Amazon

CONTROLS MUST FUNCTION... *WITHOUT PAMPERING!*

A thousand miles up the Amazon puts you about 200 miles south of the Equator—and a whale of a long way from service, as we know it. But, nevertheless, there stands the Manaus Refinaria del Companhia de Petroleo da Amazonia, complete with the most modern refining equipment.

Here, every bit of equipment must stand on its own merit... there is no time for pampering. Sources of supply and repair are too far away to help much.

So, when they hacked this refinery out of the jungle, they chose *Fisher* control valves and liquid level controls.

In a recent report, Arturo Amorim, Vice President and Director of Operations, states, "... All are delivering excellent performance"!

Which again proves that you can't beat more than three quarters of a century of *Fisher* engineering know-how for day-after-day dependability.

Manaus Refinery
COMPANHIA de PETROLEO da AMAZONIA
Designed by
SOUTHWESTERN ENGINEERING COMPANY
Los Angeles, California
Inaugurated September 6, 1956

Fluid Catalytic Cracking Unit
Designed by
UNIVERSAL OIL PRODUCTS COMPANY
Des Plaines, Illinois

CONTROL VALVES—LIQUID LEVEL CONTROLS
Supplied by
FISHER GOVERNOR COMPANY
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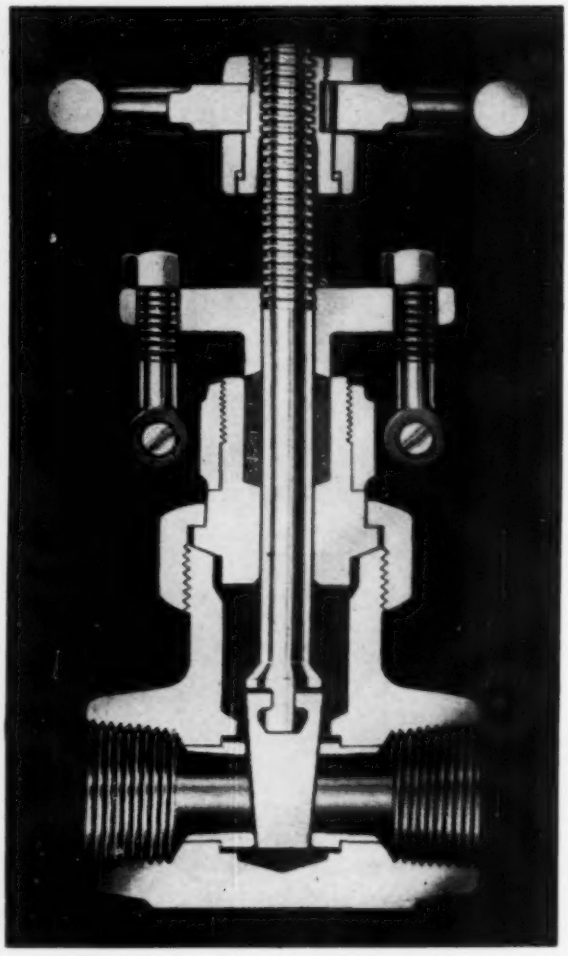
FISHER® Controls

SINCE 1880

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROLS



The Feeling is
MUTUAL

CHAPMAN LIST 960
Forged Steel Gate Valves

You want small steel valves that give the best performance and cost the least for maintenance. Chapman thinks the same way and does everything possible to give you what you want.

On Chapman List 960 Forged Steel Gate Valves the wedge faces are *super* hard. They're hardened to 800 Brinell by Chapman's exclusive Malcomizing process. They can't seize. They can't gall. They're built for rugged service.

Even the long lasting seat rings are hardened stainless steel and are very easy to replace when necessary. Also, you have no full-pressure repacking difficulties with Chapman List 960 valves.

Today, there are more Chapman List 960 valves on more jobs than any other small forged steel gate valve. Valve men and Chapman see eye to eye on performance and costs. List 960's come in sizes from ¼" to 2". They stand up perfectly under conditions from 380 psi at 1000°F. to 2000 psi at 100°F. Of course, for higher pressures you use Chapman List 990 valves.

With the 960's you can order Bonnet joint either gasketed or ground metal-to-metal. You can have rising stem with yoke or rising stem with inside screw. You find them all in our Catalog 10. Write today for a copy.

The CHAPMAN
Valve Manufacturing Co.
INDIAN ORCHARD, MASSACHUSETTS

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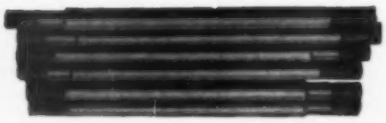
Pump rods hard-faced by ThermoSpray Process give 20 times longer service



New Metco Process hard-faced acid sludge pump rods serve as much as 20 times longer than unfaced rods.

A number of oil companies are making important savings in equipment down-time and replacement part costs with the METCO THERMOSPRAY* Hard-Facing Process. Typical of these parts are pump sleeves, as well as the acid sludge pump piston and rods shown here. Operating conditions were severe—rods had to be replaced every 24 hours—new packing every 8 hours. Hard-faced rods now last over 500 hours; packing more than 60 hours. Coatings are extremely dense and non-porous—homogeneous.

The THERMOSPRAY Hard-Facing Process consists of spraying specially developed alloys in powder form with the METCO THERMOSPRAY GUN. No compressed air is required. Coatings have hardness of Rc 30 to Rc 65, depending on the specific THERMOSPRAY alloy used; will outwear hardened steels from 3 to 10 times. Spraying speeds are higher—8 to 10 lbs. per hour—and deposit efficiency far greater (up to 97%)—than with any other type of available equipment. Hard surface depth can be closely controlled and the smooth surface left after spraying requires a minimum of finishing.

Write today for free descriptive Bulletin 126A or a call by a full-time, company-trained, Metco Field Engineer in your territory. Or see your local metallizing job shop.

The following trade names are the property of Metallizing Engineering Co., Inc.: METCO, ThermoSpray.*
**Reg. U.S. Pat. Off.*

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METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

Fact 1

Once in a while a better product is made, and made so well, that it becomes the standard by which all similar products are judged.

Fact 2

The preference that you and millions of other users have shown for the RIGID Pipe Wrench puts on us the responsibility of keeping it always up to the top quality you expect of it.

The Ridge Tool Company, Elyria, Ohio, U. S. A.

Selecting A Motor Drive For A Hazardous Area?

Here's how

TEIGF motors

by E-M

provide safe, dependable, economical power

Faced with the problem of driving hydrogen compressors in atmospheres which might contain hydrocarbons at their Baltimore refinery, engineers of Esso Standard Oil Company turned to TEIGF (Totally Enclosed Inert Gas Filled) Motors. Horsepower requirements exceeded the practicable limits under which explosion-proof motors could be used.

An important consideration was getting the greatest possible drive economy while operating safely in a possible hydrogen atmosphere. Three E-M 350 hp, 390 rpm TEIGF Motors are on duty at Esso Standard Oil Company fulfilling these important qualifications.

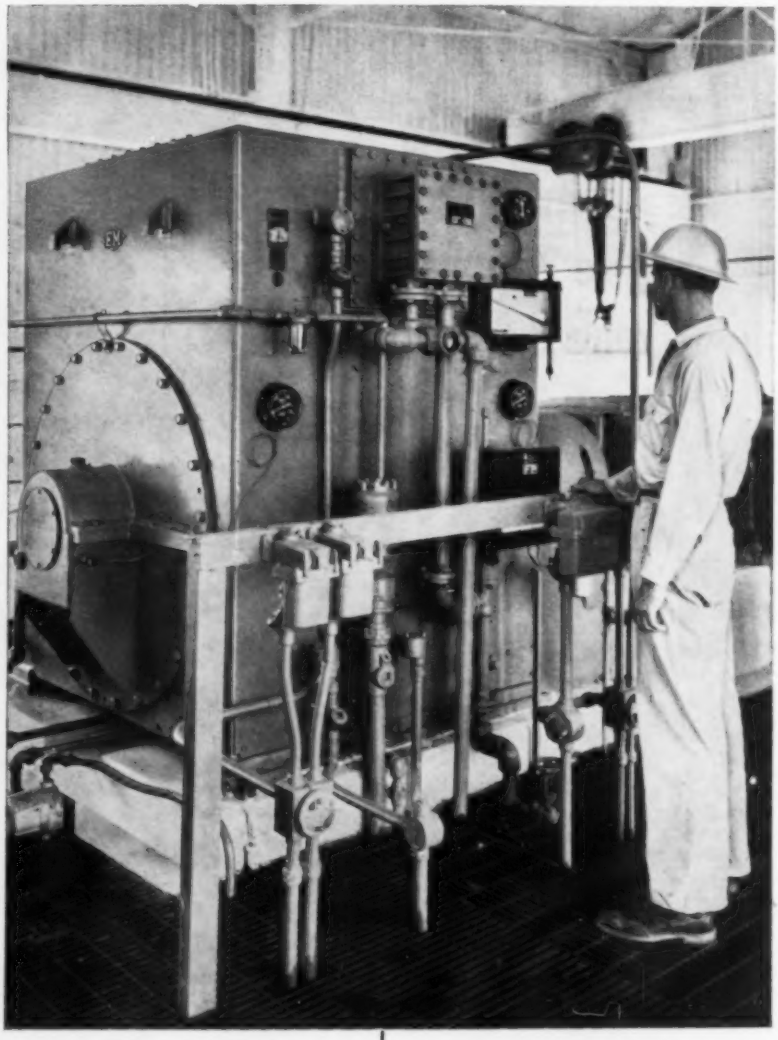
For Esso Standard Oil Company and other companies with similar problems, these E-M Motors offer three main groups of advantages:

1. SAFETY — Within the motor enclosure, inert gas pressure above atmospheric keeps explosive hydrogen *out*. A series of features help accomplish complete safety . . . inert gas pressure gauges . . . temperature gauges . . . purging valves, etc. and a full line of optional equipment. The E-M TEIGF Motor can be "customized" to meet your needs exactly.

2. RUGGED DEPENDABILITY. E-M uses specially designed "box type" frames of heavy-duty plate steel reinforced with heavy bar-stock ribs. They cannot twist or distort. Air gap is accurate and permanent, as all frame welding is completed before precision boring. Ventilating gas passages are carefully engineered to provide unimpeded gas flow for optimum cooling.

3. ECONOMICAL OPERATION. In E-M TEIGF Motors, gas loss is lower than commercially accepted standards. Specially designed shaft seals are oil-pressure gas-sealed bearing type, virtually non-wearing. Where bolts enter outside casing, E-M engineers specify blind holes . . . tapping and drilling are done *into* casing, not through. Operating and maintenance costs are at a minimum.

Consult your nearest E-M sales engineer, or write the factory for TEIGF Motor Bulletin No. 226.



TYPICAL STANDARD FEATURES INCLUDE:

1. Top-mounted gas-to-water cooler for use with suitable cooling water supply.
2. Forced-feed lubricated bearings and oil-pressure gas seals.
3. Oil pump, motor and oil filter. (Can be supplied optionally inside enclosure.)
4. Inert-gas temperature gauge.
5. Inert-gas pressure gauge.

(additional features shown in Bulletin No. 226)

TYPICAL OPTIONAL FEATURES INCLUDE:

1. Water cooler with double-tube construction for added protection against leakage.
2. Liquid level detector switch. Accumulation of moisture within motor sounds alarm or shuts down motor.
3. Bearing temperature relays, to sound alarm or shut down motor.
4. Explosion-proof motor terminal pothead or inert-gas filled terminal box.
5. Water flow indicator. Can be adapted for use with pneumatic-type regulating device.

ELECTRIC MACHINERY MFG. COMPANY

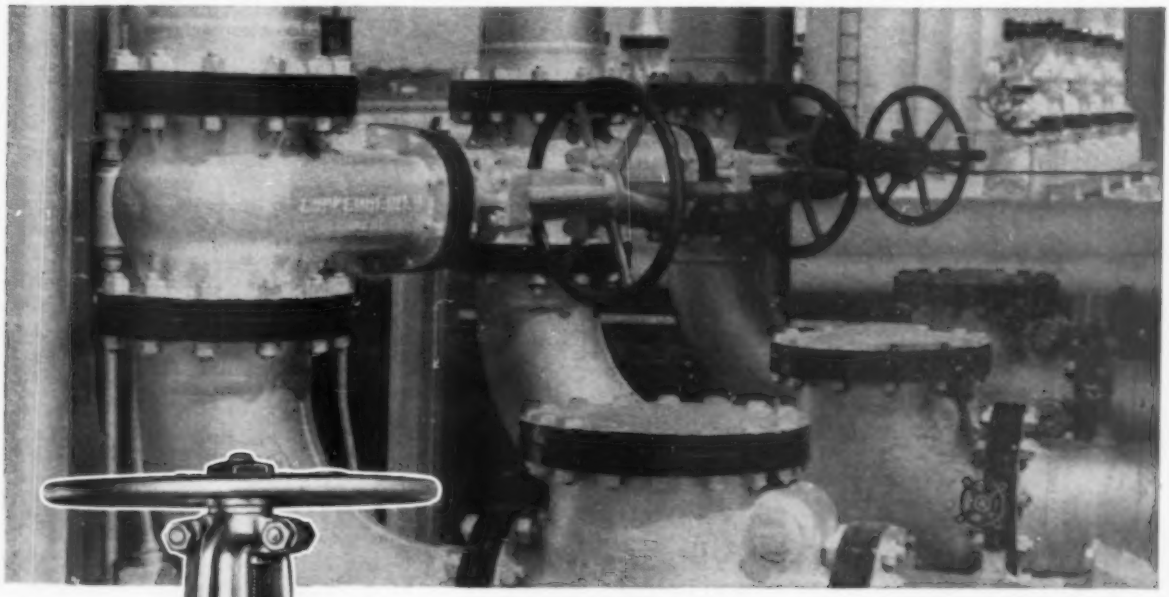
MINNEAPOLIS 13, MINNESOTA

Specialists in making motors do

EXACTLY WHAT YOU WANT THEM TO

1300—TPA—2179

Service Records Show Lunkenheimer Steel Valves Cost Less



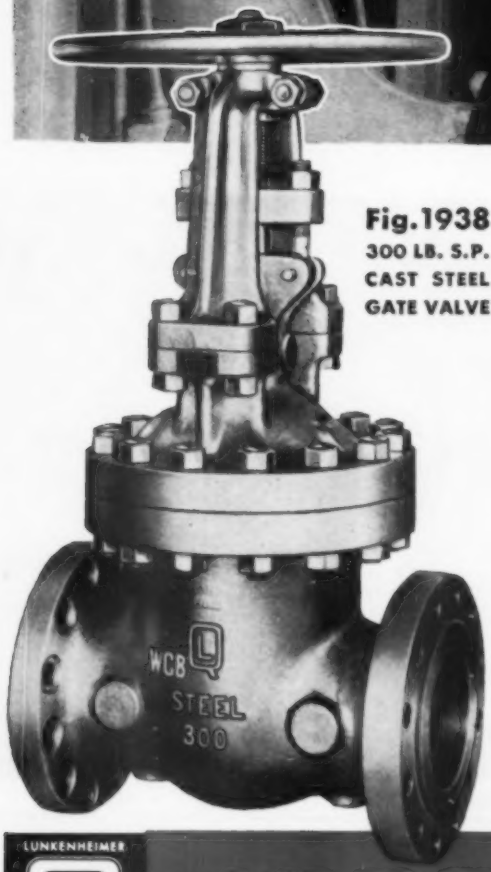


Fig. 1938
300 LB. S.P. CAST STEEL GATE VALVE

With maintenance costs up higher than ever before, the price you pay for the average valve is only a fraction of its total cost. Every time a valve needs repair, its cost rises higher and higher . . . actually dwarfing its original cost. That's why so many leading petroleum companies depend on Lunkenheimer Cast Steel Valves. Service records show that Lunkenheimer Valves cost less than any other steel valve on the market.

Lunkenheimer Steel Valves are manufactured in the industry's newest, most modern valve plant . . . with the latest precision machinery. Their outstanding design features, materials, and workmanship backed by years of experience and leadership in metallurgy, pay for themselves many times over in the maintenance dollars they save. Always insist on Lunkenheimer Valves . . . famous for quality and maintenance-free service since 1862.

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THE ONE *Great* NAME IN VALVES

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NOW..3 new International V-8's

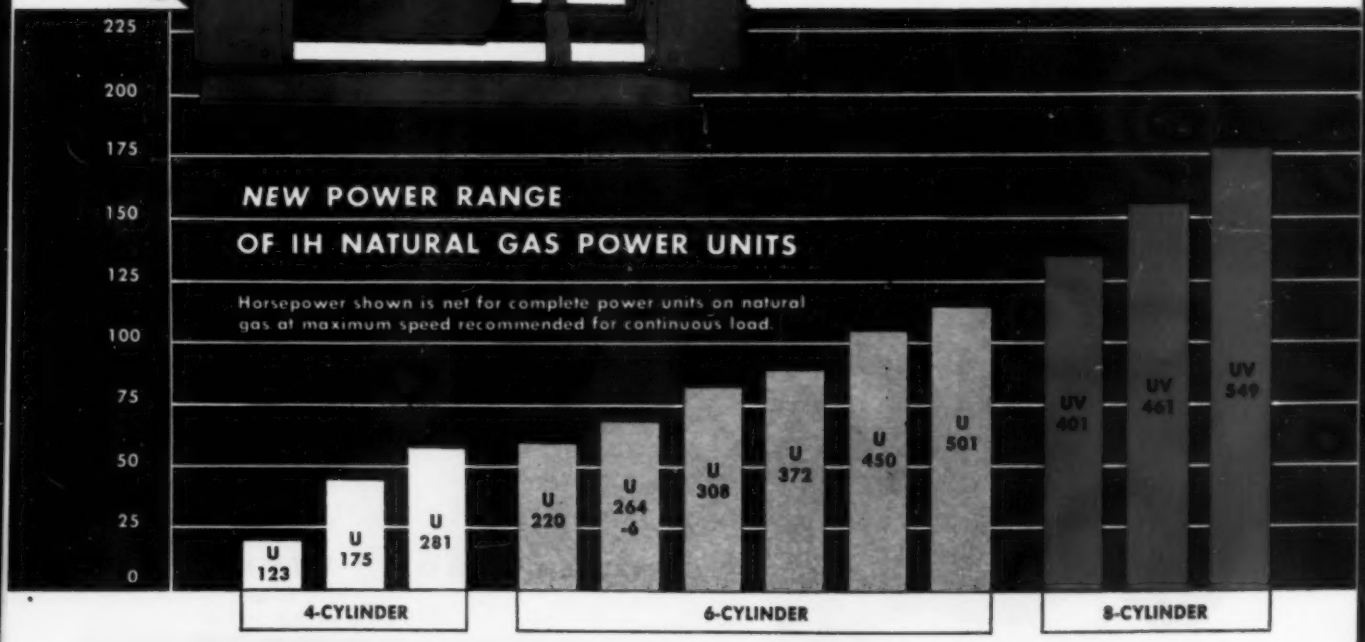
Now you have an even wider selection of economical International valve-in-head gas power for your oil field needs – three new power-packed, compact V-8's – the UV-549, UV-461, and the UV-401.

NEW V-8 UV-549 POWER UNIT. 178 net hp @ 2,600 rpm on natural gas, 200 hp on LPG, and 208 hp on gasoline. Stripped engine develops 257 hp on gasoline at 3,400 rpm.

These new V-8's increase the International carbureted line to 12 models that can be operated on the fuel of your choice—natural gas, LP gas, or gasoline. The bar chart below shows the power range of these 12 units when operating complete with radiator and fan on natural gas. Model numbers indicate piston displacement.

Standout features of the compact new V-8's that help you cut operating costs include: rigid, Y-shaped block; short-stroke, heavy-duty, cam-ground aluminum pistons; big, smooth-running, counterbalanced, tocco-hardened, 5-bearing crankshaft; large-area, long-life, tri-metal, replaceable bearings; combination full-flow, by-pass oil filter for long-life pressure lubrication; full-power, down-draft carburetion; oil cooler; and a 12-volt electrical system.

For the best in dependable power for your pumping, exploratory drilling and servicing rigs, it will pay you to investigate this new International line. You'll get power that outperforms with more in-built values. You'll get power that's backed by fast, efficient parts and service support available to customers throughout the world.



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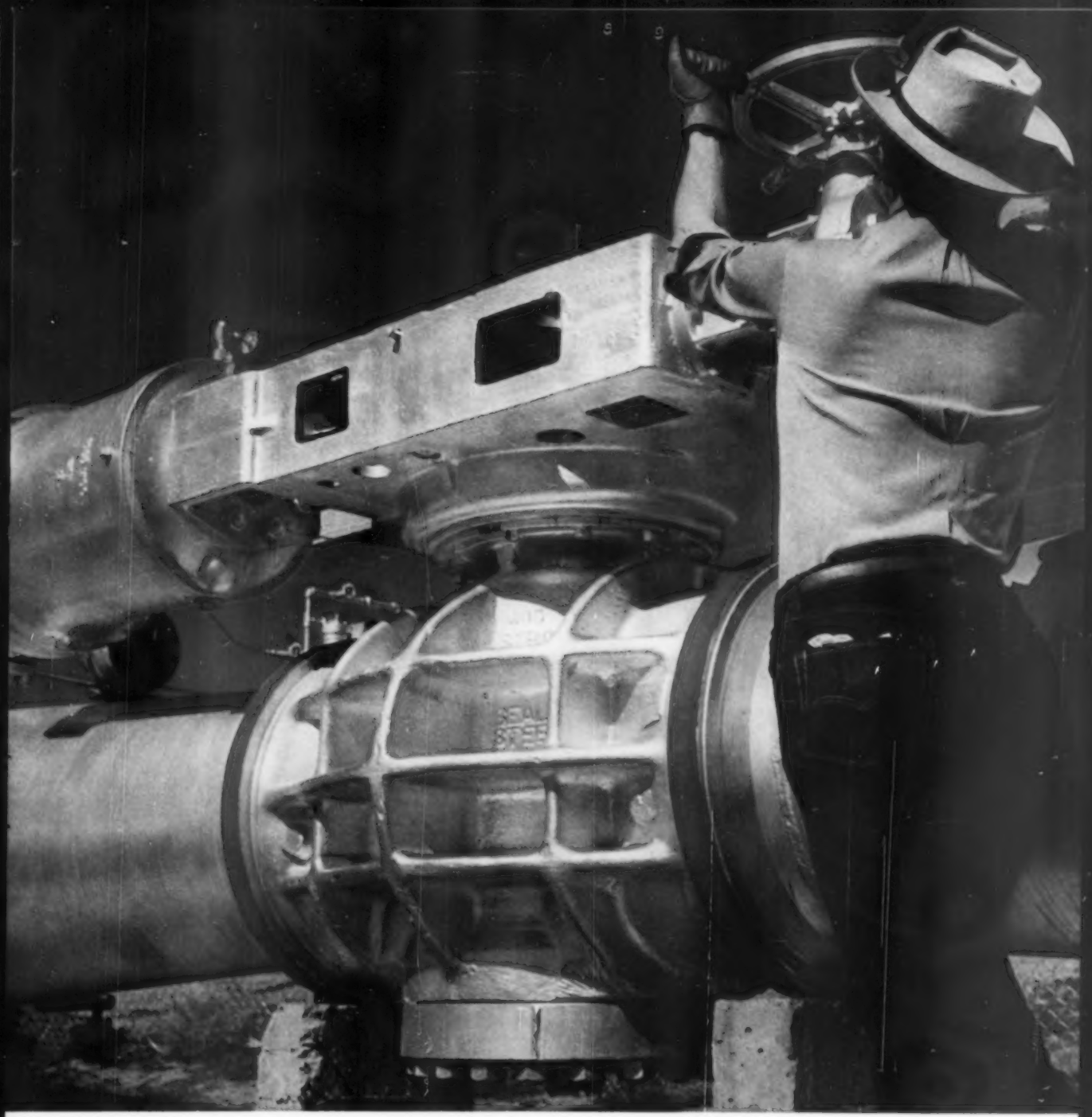


EMERGENCY! Are you sure your key valves will operate when an emergency comes? They will, *if* they are Rockwell-Nordstrom valves with *pressurized lubrication* that makes operation fast, easy and *sure*.

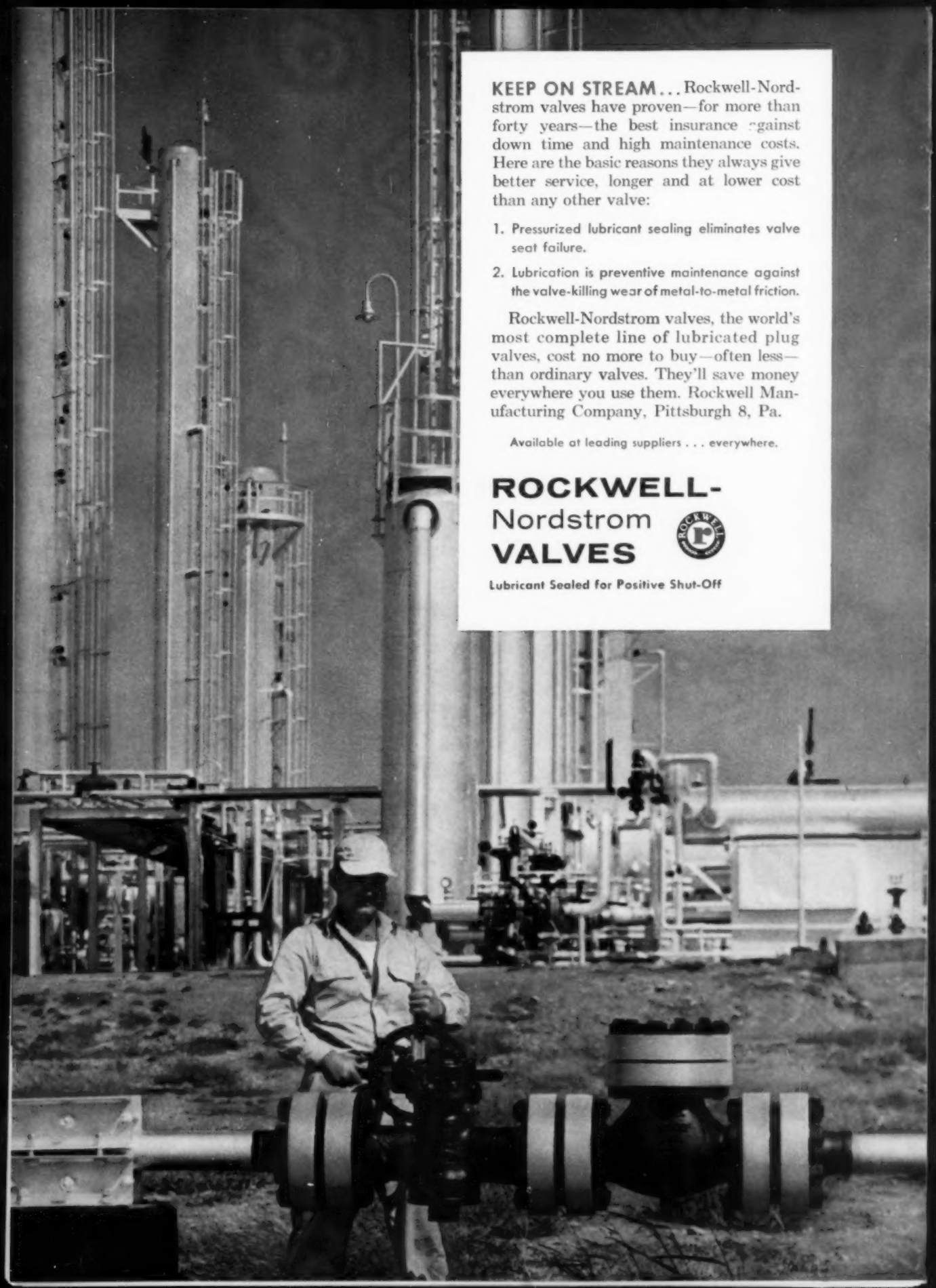
Unlike the forced seating in ordinary valves, the Rockwell-Nordstrom valve plug is kept friction-free by lubricant—frozen or stuck valves are eliminated. And quarter-turn closure is two to five times faster.

The lubricant in Rockwell-Nordstrom valves does another important job: it eliminates metal-to-metal wearing friction for longer valve life. Yet with all their obvious advantages, Rockwell-Nordstrom valves cost no more to buy, often less, than ordinary valves. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed For Positive Shut-Off



KEEP ON STREAM... Rockwell-Nordstrom valves have proven—for more than forty years—the best insurance against down time and high maintenance costs. Here are the basic reasons they always give better service, longer and at lower cost than any other valve:

1. Pressurized lubricant sealing eliminates valve seat failure.
2. Lubrication is preventive maintenance against the valve-killing wear of metal-to-metal friction.

Rockwell-Nordstrom valves, the world's most complete line of lubricated plug valves, cost no more to buy—often less—than ordinary valves. They'll save money everywhere you use them. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Available at leading suppliers . . . everywhere.

ROCKWELL-
Nordstrom
VALVES

Lubricant Sealed for Positive Shut-Off

BOTH ARE Fibercast® WELL TUBING ONE IS NEW...THE OTHER WAS IN A SALT WATER DISPOSAL WELL FOR 17 MONTHS!

All photos are unretouched

The tubing on the left above is new — the other, was in a salt water well for 17 months.

There's no noticeable nor measurable difference between the new coupling on the left and the one that was in salt water for 17 months!

You can't tell the difference — because Fibercast® will not corrode

Anyone who has pulled a string of tubing after several months and found it corroded beyond practical use will truly be impressed with *this actual experience*. The length of Fibercast on the left above was in a salt water disposal well for 17 months . . . the one on the right is new. Yet, because Fibercast is unaffected by corrosion-causing elements, there is no noticeable — and, more important, *measurable* — difference.

Corrosion eats away dollars as well as the pipe; that is, most pipe . . . but not Fibercast, because "Fibercast *will not* corrode." Too, Fibercast has other greatly desired advantages . . . high operating temperatures and pressures . . . lightness . . . and long-term economy. Send the coupon for complete details.

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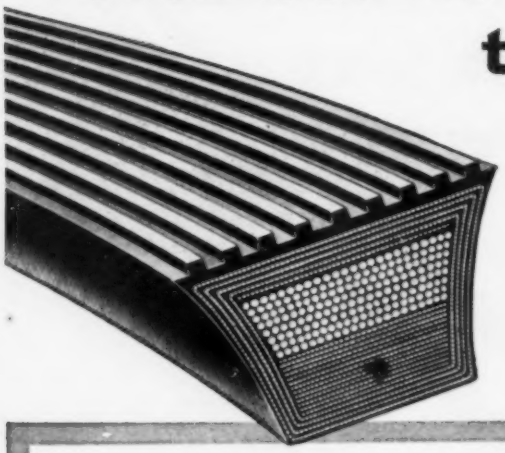


4 important engineering developments insure top performance from Rib-Top

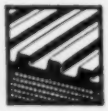
1. Tougher, more resilient cords

are able to absorb the severe pulsation of mud pumps; easily handle peak loads.

2. Concave Sidewalls (U.S. Pat. 1813698)

Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt... far longer belt life.

3. Stabilizing ribbed tops (U.S. Pat. No. 2548135)



— exclusive with Gates. Dampen vibration; protect top of belt; keep it running smoothly over idler-equipped mud pump drives without side whip.

4. Flex-Weave cover (U.S. Pat. No. 2519590)

provides greater flexibility with far less stress on fabric. Wears longer... lengthens belt life... lowers belt costs.

TPA-160

Used by more drillers on more mud pump drives than any other V-belt, Gates Rib-Top Vulco Rope is everywhere recognized as the outstanding performer in this tough service.

Rib-Top was developed *especially* for mud pump drives in the world's largest belt development center — at Gates — but costs no more than ordinary belts of comparable ratings. Available in Standard and Super at your oil field supply store.

Use Super Rib-Top for the tougher drives

With 40% greater horsepower capacity, Super Rib-Top easily handles drive overloads. Fewer belts and narrower sheaves solve space and weight problems.

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World's Largest Maker of V-Belts

Gates Rib-Top Vulco Rope

DEVELOPED ESPECIALLY FOR MUD PUMP DRIVES

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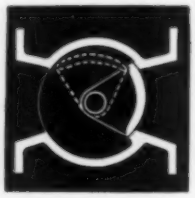
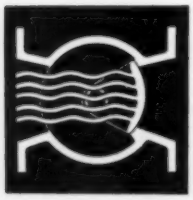
In all that time — on this wide variety of services — not one DeZurik Valve has failed. In fact, the refinery reports, in addition to *never needing lubrication, DeZurik Valves have never required maintenance of any kind on any of these services.*

HERE'S WHY!

DeZurik's *exclusive* eccentric action guarantees easy operation and tight shut-off — despite solids in the flow — without constant lubrication maintenance. The plug in a DeZurik Valve is pivoted eccentrically — never touching the valve body, except when closed TIGHT!





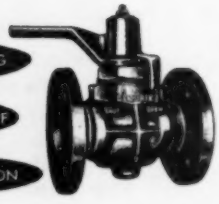
The resilient plug-facing material provides cushioned closure — sealing tight with solids intervening as well as on gas or air lines. Because the plug touches the body only when the valve is closed, DeZurik Valves need no lubrication to provide easy operation — never "freeze" open — *always* operate easily!

*name on request

Get more information on these outstanding valves.

Representatives in all principal cities, or write

EASY-OPERATING
TIGHT SHUT-OFF
NO LUBRICATION



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SARTELL, MINNESOTA

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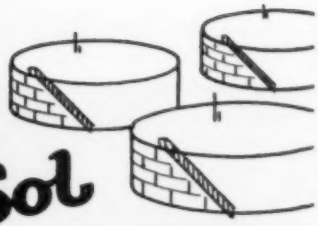

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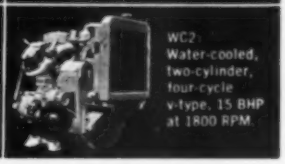
AC2: Air-cooled, two-cylinder, four-cycle v-type, 14 BHP at 1800 RPM.

WC1: Water-cooled, one-cylinder, four-cycle, 7 BHP at 1800 RPM.



WC2: Water-cooled, two-cylinder, four-cycle v-type, 15 BHP at 1800 RPM.

AMERICAN MARC also manufactures Diesel generating plants from 3 to 10 KW (AC or DC, and industrial three-phase), Diesel pumping units from 48 to 1700 GPM, marine propulsion, refrigeration units and power-packages for other services. American MARC can adapt any of its Big 4 engines to fit every job requiring from 5 to 20 BHP.

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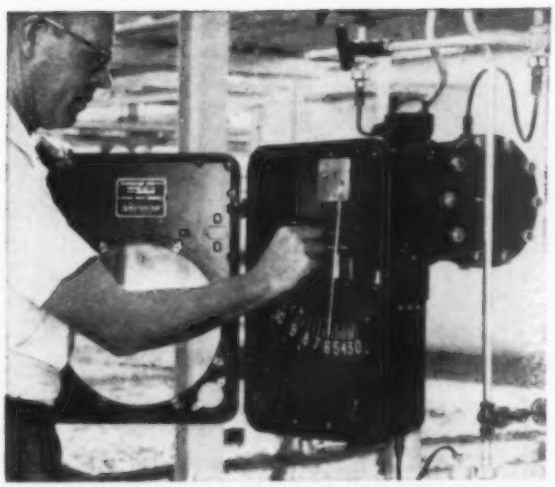

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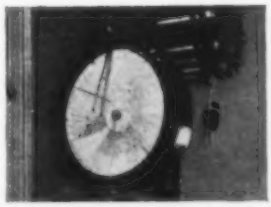
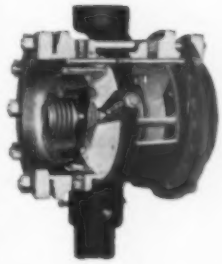
Below, a DRI-FLO manometer is shown measuring lease gas and is used in conjunction with a 30-year-old recording mechanism — proof of the versatility and long service life built into American products.





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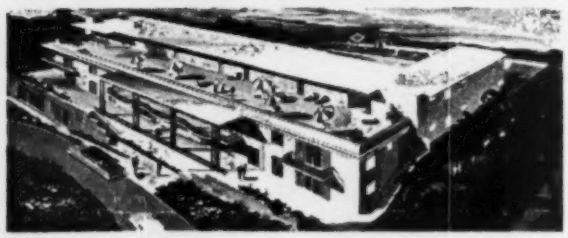

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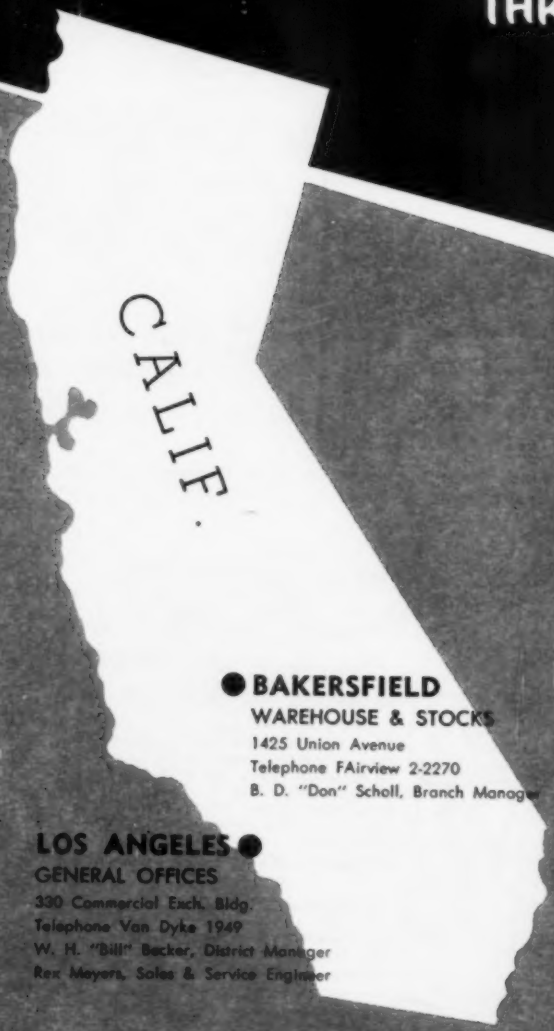

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B. D. "Don" Scholl, Branch Manager

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GENERAL OFFICES
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WATER KNOCKOUTS
EXCLUSIVE DISTRIBUTOR OF ARMCO SURFACE CASING THROUGHOUT THE UNITED STATES AND CANADA

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

Good equipment PUTS *Pride*

IN A GOOD CREW

When there's pride in equipment, a good crew does a better job.

Franks Rocket — favored among contractors, crews, and oil companies alike — is designed for speed with ease of operation and safety.

Rig-up is faster. The telescoping derrick remains strung during moves. The derrick raises hydraulically. Leveling is simple, fast. Only guy line to unit needed.

Operation is faster with the air lift transfer. Models from 6,500 to 12,000 ft. See a Franks representative for details or write.

FRANKS DIVISION
Cabot Shops, Inc.
Pampa, Texas

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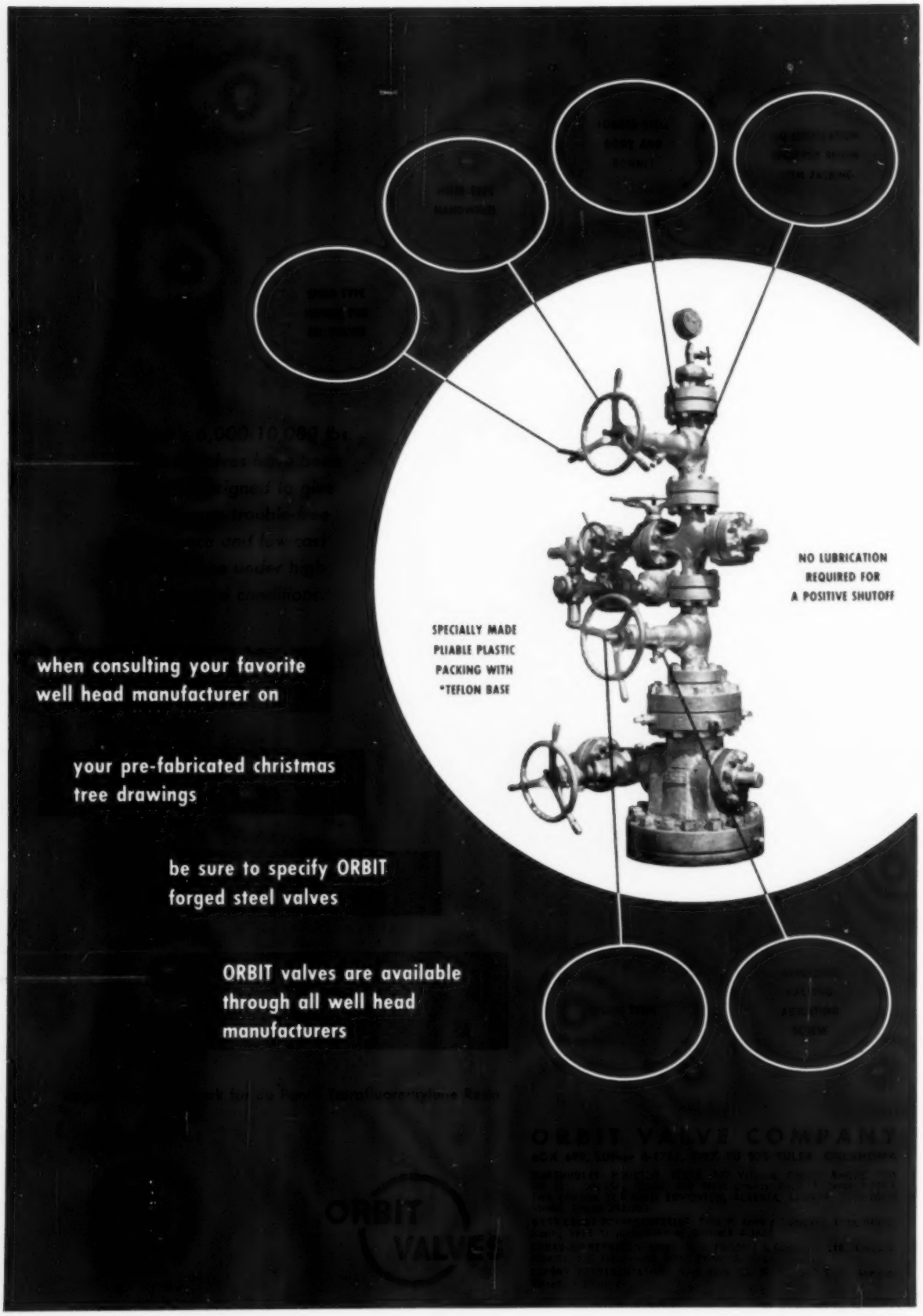
when consulting your favorite well head manufacturer on
your pre-fabricated christmas tree drawings
be sure to specify ORBIT forged steel valves
ORBIT valves are available through all well head manufacturers
SPECIALLY MADE PLIABLE PLASTIC PACKING WITH *TEFLON BASE
NO LUBRICATION REQUIRED FOR A POSITIVE SHUTOFF
ORBIT VALVE COMPANY
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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Of Things To Come . . . In Oil

LAST QUARTER CRUDE OUTLOOK BETTER than last year, but far from earlier expectations, according to IPAA's monthly forecast. Market for domestic crude to average about 7.2 million bbl daily . . . 300,000 bbl per day over September.

OFFSHORE DRILLING IN 1000 FT OF WATER, and deeper, has been accomplished in the development of a revolutionary new method patented by the CUSS Group (Continental, Union Oil of California, Shell, and Superior). Idea utilizes a floating vessel containing drilling equipment. Control head is anchored on ocean bottom. Over 300,000 ft of hole has been drilled by the new idea, even in depths up to 1500 ft.

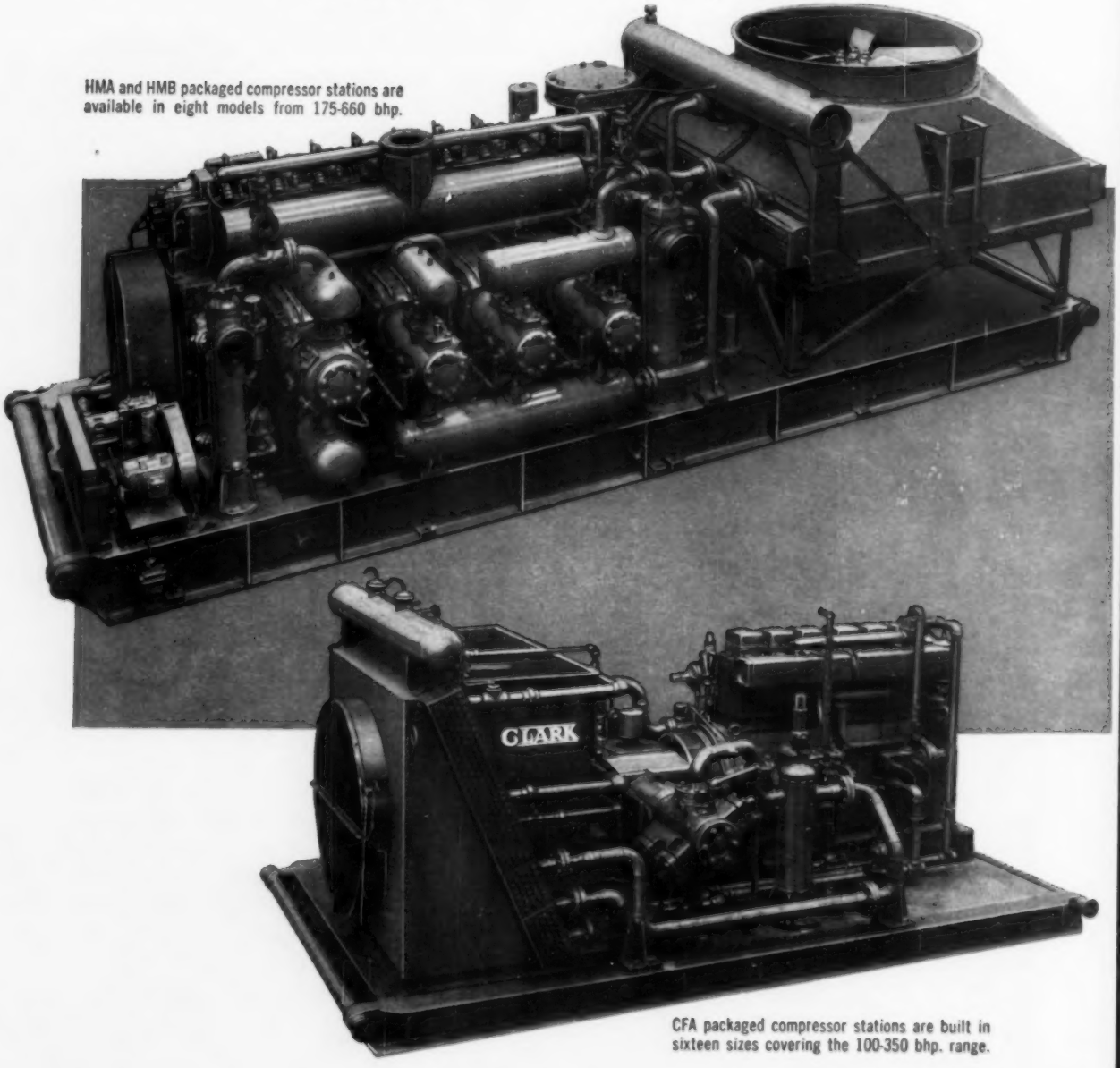
SURFACE LOGGING OF CORE SAMPLES has proved in field tests to be of great significance in evaluating logs taken in the well. Logs are actually run on the core sample on the surface to better correlate at the well site conventional logs. It should be a boon to geologists, and will be announced shortly.

SHOWDOWN ON IMPORTS may come later this fall, according to many signs. Although imports for September and October were down, independent domestic producers are mustering strength to push strict federal control. Some favor higher import duty. Outcome still hazy and may take one of several forms.

AMERICAN OIL INTERESTS OUTSIDE THE U. S. WILL GROW substantially in the coming year although crude imports to this country will stabilize. Growing market for free world oil makes American investments in oil exploration and development increasingly appealing, and more foreign governments are coming to like money and industrial development brought by the oil search. Ralph O. Rhoades, senior vice president of Gulf Oil Corporation, points out "that the interests of American oil companies in the foreign producing regions of the world are of great importance to the people of the free world — and to the U. S."

STATE OIL ALLOWABLES WILL NOT FALL "one drop" lower, state after state agency declares, after seeing several months of scarce oil production. More purchaser proration may be seen however, and crude prices in various parts of the country will continue to "adjust." Esso Standard cuts its purchases in Louisiana and Mississippi in October and the Ohio Oil Company cut prices of heavy crudes in Wyoming. It is noted that Magnolia Petroleum Company ceased its proration and is now taking full allowables in Texas and Louisiana.

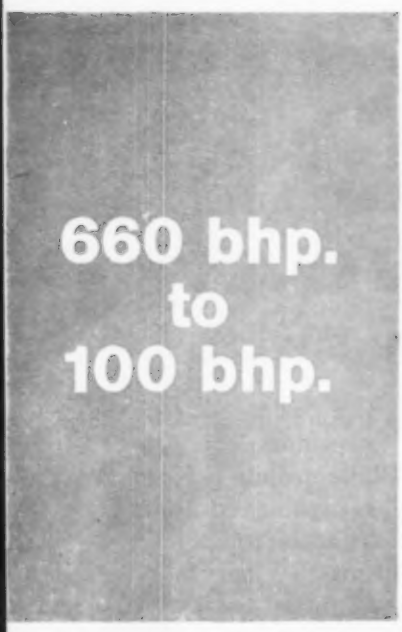
With Clark packaged compressors there are 24 SIZES TO .....



HMA and HMB packaged compressor stations are available in eight models from 175-660 bhp.

CFA packaged compressor stations are built in sixteen sizes covering the 100-350 bhp. range.

CHOOSE FROM !



Excess horsepower in a field compressor, above and beyond its inherent overload carrying ability, is fine if you have a use for it. But when it is horsepower that can't be made to earn its way, it's money down the hole.

With twenty-four sizes to choose from, Clark can deliver a packaged compressor that's tailored exactly to your horsepower needs in the 100-660 bhp. range. You can realize substantial savings by avoiding the installation of an improperly sized unit just because "it's all that's available".

When you need flexibility, Clark can give you that also. Every Clark field compressor has a maximum number of compressor cylinders. With many units, you can work two sands simultaneously or, if you have to move a unit to a new field, radically different operating conditions can be handled with a minimum of change-over.

Clark CFA, HMA and HMB packaged field compressors are proved machines. They are the only field compressors available that have been specifically designed for the job. Their balanced/opposed design eliminates the need for massive foundations . . . just enough to level them is ample.

Your nearest Clark office has a specialist on field compressors. Call him . . . he will be pleased to give you all the facts and figures.

CLARK BROS. CO. **OLEAN, NEW YORK**
One of the Dresser Industries
Offices in Principal Cities Throughout the World

CLARK®

Packaged Compressor Stations

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

BLUE WATER NO. 1

...another example of INGALLS' SKILL

The INGALLS-built "Blue Water No. 1" is the first submersible offshore drilling platform built for the new Blue Water Drilling Corporation. It is the prototype of a new design in offshore "rigs"... a design already proved in offshore drilling operations. Commissioned September 6, 1957, this huge new "rig" is capable of drilling six wells without relocating in water up to 70 feet deep. It measures 242 feet in length, 202 feet in depth, 262 feet from barge to top of mast... has a helicopter landing deck... and provides air-conditioned accommodations for a crew of 50. The "Blue Water No. 1" is one of many INGALLS-built "rigs" exploring new oil frontiers along the Gulf's Continental Shelf.

If your next offshore drilling job calls for imagination and economy, experience and technical skills... consult a specialist—INGALLS.

THE INGALLS SHIPBUILDING CORPORATION

Executive Offices: Birmingham, Alabama

Branch Offices: New York, Washington, New Orleans, Chicago, Philadelphia, Atlanta, Houston

Shipyards: Pascagoula, Mississippi; Decatur, Alabama; Arnold V. Walker Shipyard, Inc., Pascagoula, *a subsidiary*

Complete Dry Docking Facilities at Ingalls Decatur yard

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DESIGNERS AND BUILDERS of Offshore Service Vessels, Commercial and Drilling Barges, Tankers, Naval, Merchant Vessels

ENGINEERS: for jobs with a future, contact Ingalls today

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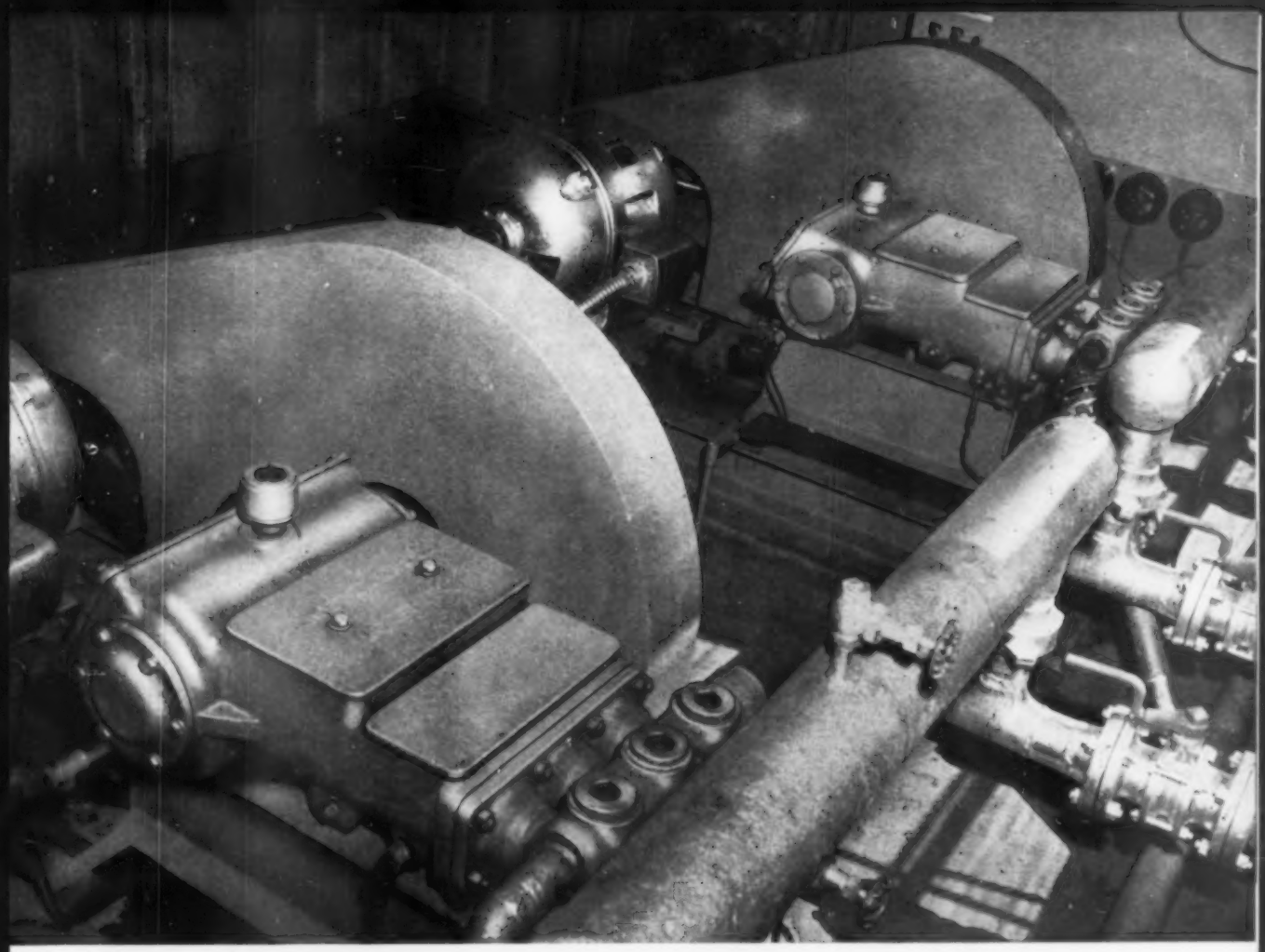

Put These Tough Little Power Pumps on Waterflood and Disposal Jobs

You're apt to run into 'most anything on waterflood jobs, and the same is true of salt-water disposal. That's why Bethlehem has gone all out to build the toughest, most durable pumps ever offered for these types of service.

The Bethlehem line includes two triplex models—the TP-3 and the somewhat larger TP-4. These are unusually rugged units with a controlled gravity-flow lubrication system. Oil floods the power end at all speeds, high or low, and the system starts up with the first turn of the gears. Positive, dependable lubrication is one of the reasons why TP's can be operated continuously under full load.

Fluid ends are available in molybdenum alloy iron, cast steel, and aluminum-bronze, and in all cases the proper complementary trim is furnished. Plungers are of hardened steel, stainless steel, or solid ceramic. This range of combinations makes the TP's suitable for many uses—not only in waterflooding and disposal work, but also in crude-oil gathering and the handling of refinery products.

The pumps can be fitted with an optional speed-reducer, which is easily installed in the field. This device is adaptable for either right-hand or left-hand drive, and can of course be used with standard oil-field engines or motors.

In addition to its TP triplex units, Bethlehem makes duplex models known as the U-series. Thus it is possible to select exactly the proper size and type of pump to meet your needs. When you are next in the market, get complete information from the nearest Bethlehem office.

BETHLEHEM GENERAL-SERVICE PUMPS

Model	Type	Plunger Load, lb	Input hp	Bore & Stroke, in.
TP-3	Triplex	3580	36 @ 400 rpm (max)	1 ¾ to 2 ¼ x 3
TP-4	Triplex	5000	67 @ 400 rpm (max)	2 to 4 x 4
U-33	Duplex	2400	13 @ 160 rpm	1 ¾ to 3 x 3
UA-46	Duplex	5000	40 @ 120 rpm	2 ½ to 4 x 6
U-510	Duplex	12000	100 @ 75 rpm	3 to 5 ½ x 10

BETHLEHEM SUPPLY COMPANY
General Offices: 21 E. Second St., Tulsa, Okla.
West Coast Headquarters: Los Angeles, Calif.
Canadian Distributor: Bethlehem Supply Company of Canada, Ltd
Calgary, Alberta, Canada
Export Distributor: Bethlehem Steel Export Corporation
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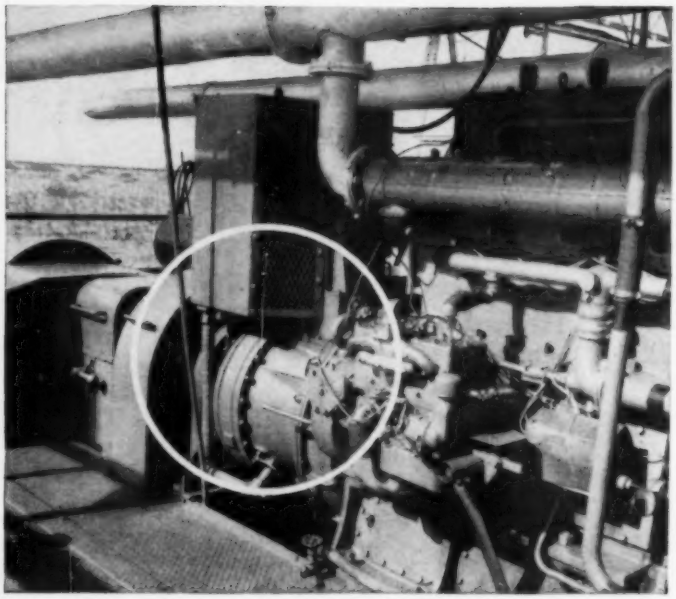
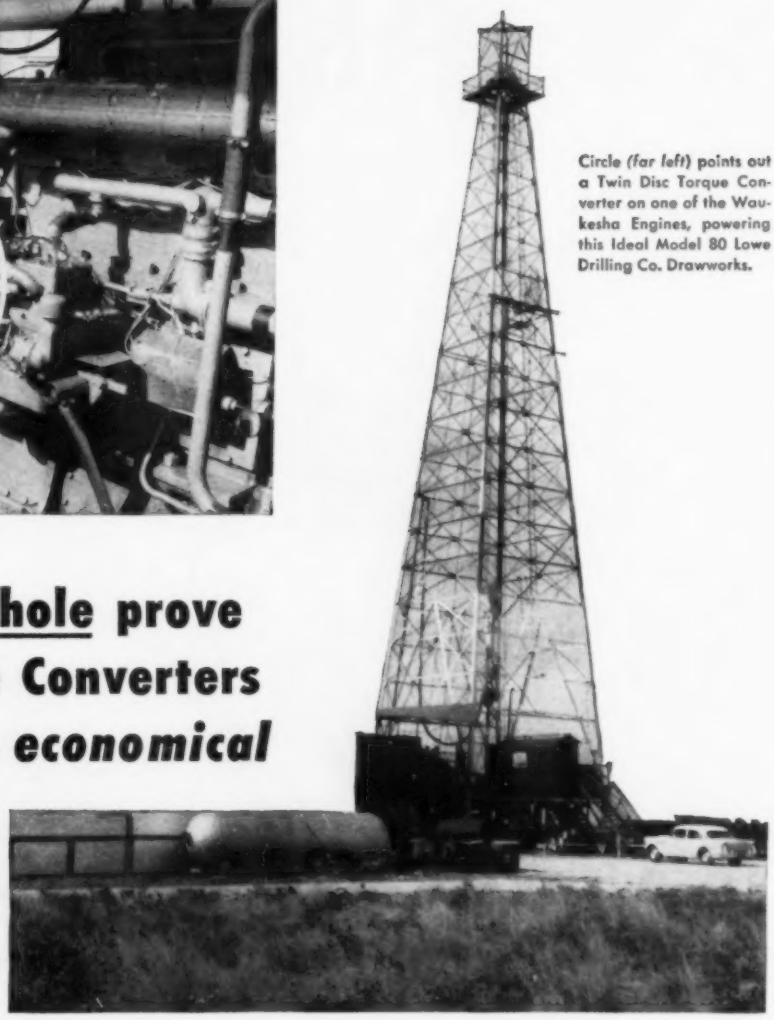
BETHLEHEM SUPPLY



Circle *(far left)* points out a Twin Disc Torque Converter on one of the Waukesha Engines, powering this Ideal Model 80 Lowe Drilling Co. Drawworks.



120,000 feet of hole prove Twin Disc Torque Converters are *dependable, economical*

With four years and 120,000 feet of hole behind them, two Twin Disc Torque Converters—owned by Lowe Drilling Company of Midland, Texas—are still in tip-top shape. The *only* service necessary was the replacement of an oil pump.

The torque converters are mounted on two 450-hp Waukesha Model LRZ gas engines, transmitting power to an Ideal Model 80 Drawworks.

In addition to their *durability and dependability,* the torque converters deliver *more power* by allowing the engines to operate within maximum power range under a wide variation of loads. The exact speed ratio required is *automatically* selected for every operation.

Through *fluid* connection, the Twin Disc Torque Converters cushion *out* harmful shocks and vibrations—thus *increasing* machinery life, *reducing* engine wear and *minimizing* costly downtime.

Twin Disc has a complete line of torque converters, both single-stage and three-stage, for every horsepower range from 30 to 1000—offering a wide variety of capacities and a broad range of input, output combinations.

Take advantage of the many cost-cutting, profit-making features of Twin Disc Torque Converters. For complete details, contact the Twin Disc District Office nearest you . . . Tulsa: Enterprise Building, Sixth and Boston, GIbson 7-1578. Dallas: 1511 Turtle Creek Boulevard, RIverside 3014. Los Angeles: 2950 Leonis Boulevard, LOgan 8-3309.

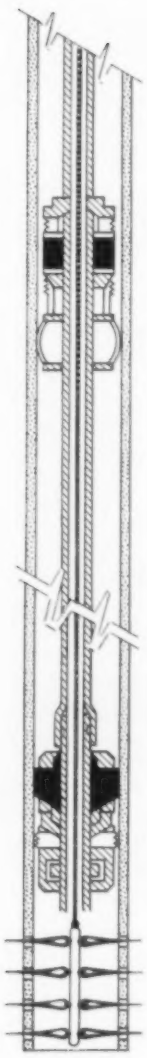
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

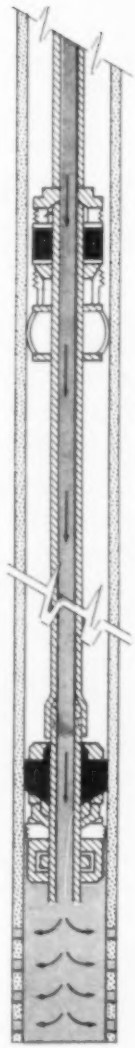
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • TULSA

Here is an UNBEATABLE Full-Opening Retrievable Bridge Plug Assembly...

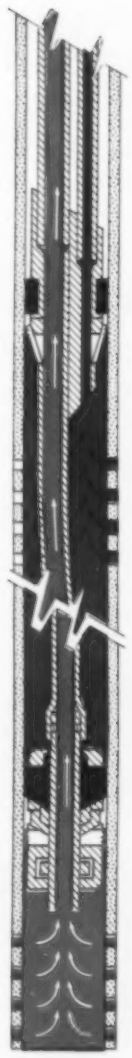


Shooting Lower Zone
BP-4 and Boll Weevil run in hole together. Through-tubing perforator run through full-opening Retrievable Bridge Plug.



Stimulating Lower Zone
Built-in hydraulic hold-down actuated by pressure below the Bridge Plug Packer prevents tool from pumping up hole even under severe differential pressures.

Testing Upper Zone
Move full-opening Bridge Plug above upper zone, perforate with tubing gun, lower tubing, reset bridge plug between perforations, blank off lower zone with tubing plug, release tubing and set Brown Boll Weevil packer above upper zone. Dependable Brown Boll Weevil Packer allows swabbing or stimulation of upper zone.



Producing Two Zones
Type BP-4 Bridging Plug Packer left in hole as lower production packer. Boll Weevil replaced by dual string packer and tubing plug removed. Producing two zones with Brown PRIME* Completion Tools.

Brown Type BP-4 Retrievable Bridging Plug Packer

Brown Boll Weevil Packer

- Safely work each zone under pressure with this combination and eliminate the necessity of killing a good well.
- When testing and treating is completed leave the Type BP-4 Bridge Plug in the hole as a production packer.
- Tripping tubing to remove the upper packer is safely accomplished with the zones below bridging plug blanked off.

Contact your nearest Brown representative for full information on all Brown tools and services.

BROWN
OIL TOOLS, INC.

*Parallel Retrievable Independent Multiple-String Equipment

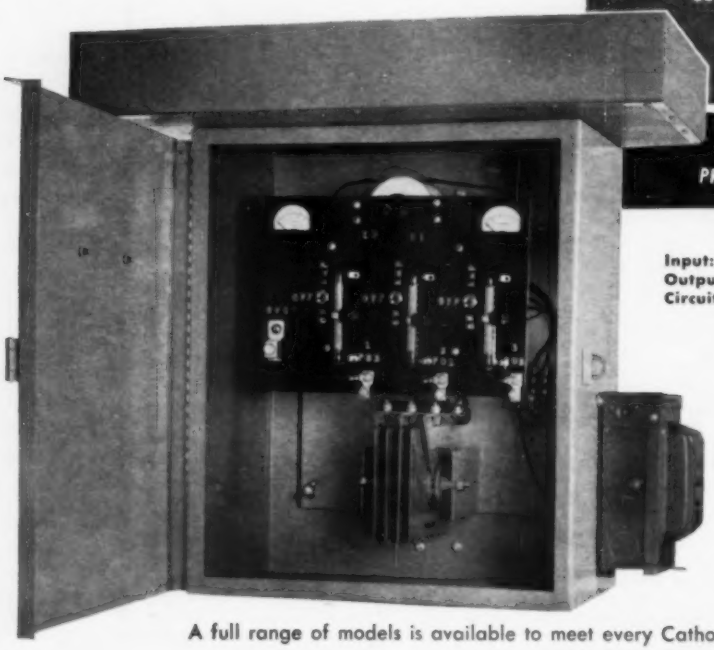
Catalog on Prime Completion tools just off the press.

HOLCOMBE
CATHODIC PROTECTION RECTIFIERS

PREVENT CORROSION OF WELL CASINGS, STORAGE TANKS, HEATER TREATERS, SALT WATER SYSTEMS AND PIPE LINES

SPECIALLY DESIGNED for oil field use, Holcombe rectifiers have behind them, the experience of hundreds of field installations and sixteen years development of corrosion prevention products. Each unit is individually load-tested before shipment.

THE HIGHEST QUALITY COMPONENTS
HIGH EFFICIENCY FACTOR
EASY TO INSTALL
READILY ACCESSIBLE
WEATHER PROOF
LONG WARRANTEE



MODEL USED FOR PROTECTION OF HEATER-TREATER.

Input: Any single phase voltage
Output: 6 volts 15 amperes D.C.
Circuits: 3 positive anode circuits, each rated at 5 amperes, individually adjustable, and individually metered.

A full range of models is available to meet every Cathodic protection need.

Write for information on Holcombe Cathodic protection rectifiers.

THE HOLCOMBE COMPANY, INC.
FIRST NATIONAL BANK BUILDING TELEPHONE 5-3468 SHREVEPORT, LOUISIANA

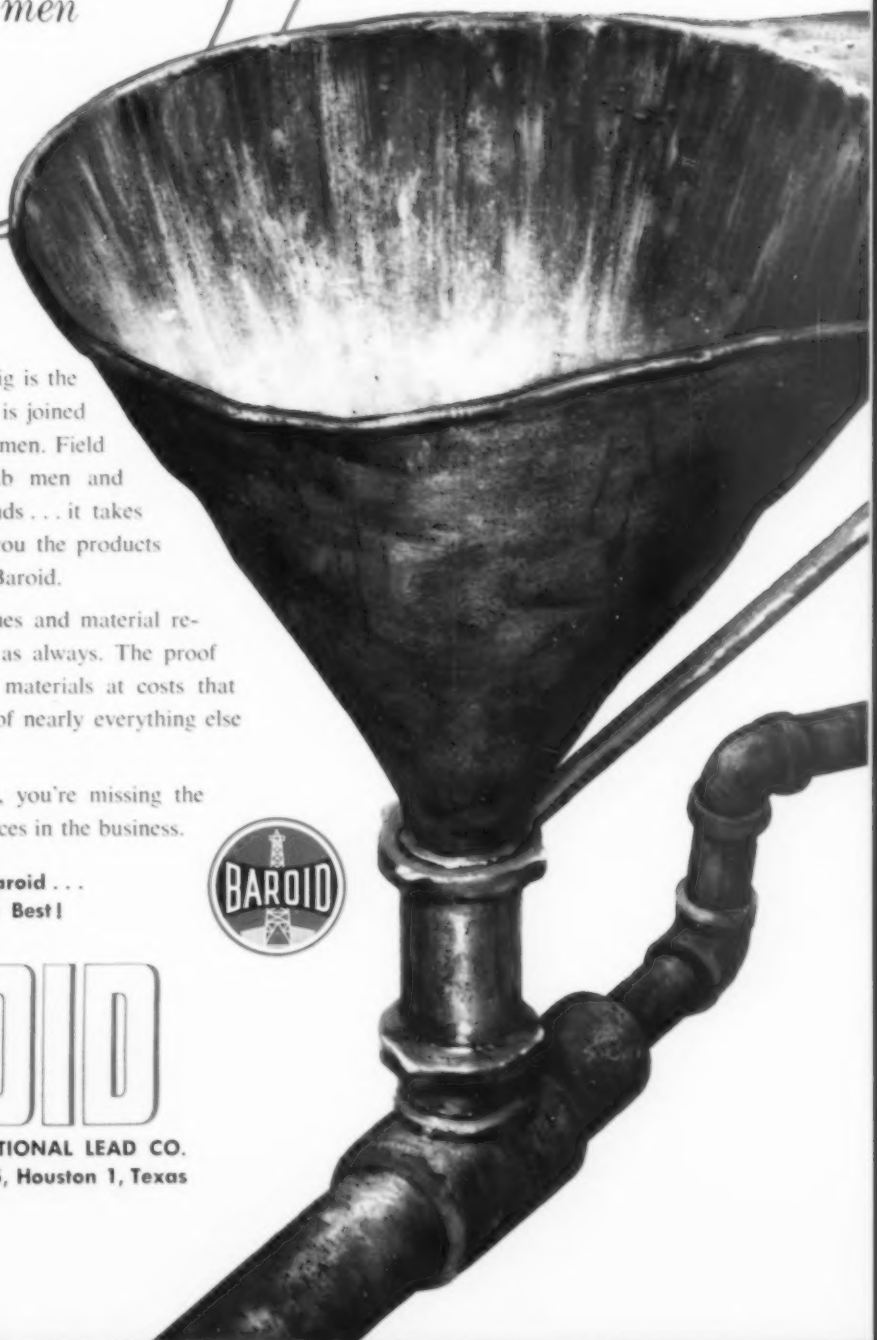
HOLCOMBE COMPANY OF CANADA, INC.
323 BARKER BUILDING TELEPHONE 6-7291 CALGARY, ALBERTA, CANADA

LION COATINGS • HOLCOMBE SELENIUM RECTIFIERS
PIPE WRAPPINGS • GRAPHITE ANODES • COKE BREEZE

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

No moving parts

. . . yet its operating crew includes more than 2,000 Baroid men



The mud hopper at your rig is the point where your own crew is joined by more than 2,000 Baroid men. Field engineers and foremen, lab men and loggers, miners and millhands . . . it takes a big organization to give you the products and services you get from Baroid.

In manpower, facilities, mines and material reserves, Baroid leads today, as always. The proof is at your rig: better mud materials at costs that have risen *less* than prices of nearly everything else you use in drilling.

If you're not using Baroid, you're missing the best mud products and services in the business.

When you buy Baroid . . .
. . . you buy the Best!

BAROID

BAROID DIVISION • NATIONAL LEAD CO.
Main Office: P. O. Box 1675, Houston 1, Texas

5798

Baroid's new **SHALE BAN*** *ends shale trouble*

DRILL THICK SHALE FORMATIONS WITH LESS TROUBLE

SHALE BAN* additive makes a chemical mud that inhibits hydration and dispersion of formation clays both as shales and as clay particles in sands. This means lower mud and drilling costs—greater probability of successful drilling of long mud making shale formation—and less damage to dirty sands.

*Trademark, Baroid Division National Lead Company.

1. SHALE BAN additive reduces the build-up of drilled solids; results in less mud to condition with weight materials, chemicals and filter loss reducing agents because less mud is made.
2. SHALE BAN additive keeps the hole to gauge resulting in less mud volume to treat—more efficient cuttings removal and less cement when casing is set.
3. SHALE BAN additive reduces tendency of drill pipe to stick during salt-water flows because the shales are "pickled" by the mud filtrate and the mud is tolerant to salt-water.
4. SHALE BAN additive can result in production increases because clays do not hydrate and swell to reduce permeability. Flocculated mud particles are less likely to penetrate sand formation pores.

Specify SHALE BAN mud and get the advantages of less mud cost, lower drilling cost, less trouble and increased production. Write now for technical bulletin.

When you buy Baroid — you buy the Best!

BAROID

BAROID DIVISION • NATIONAL LEAD CO.
Main Office: P. O. Box 1675, Houston 1, Texas

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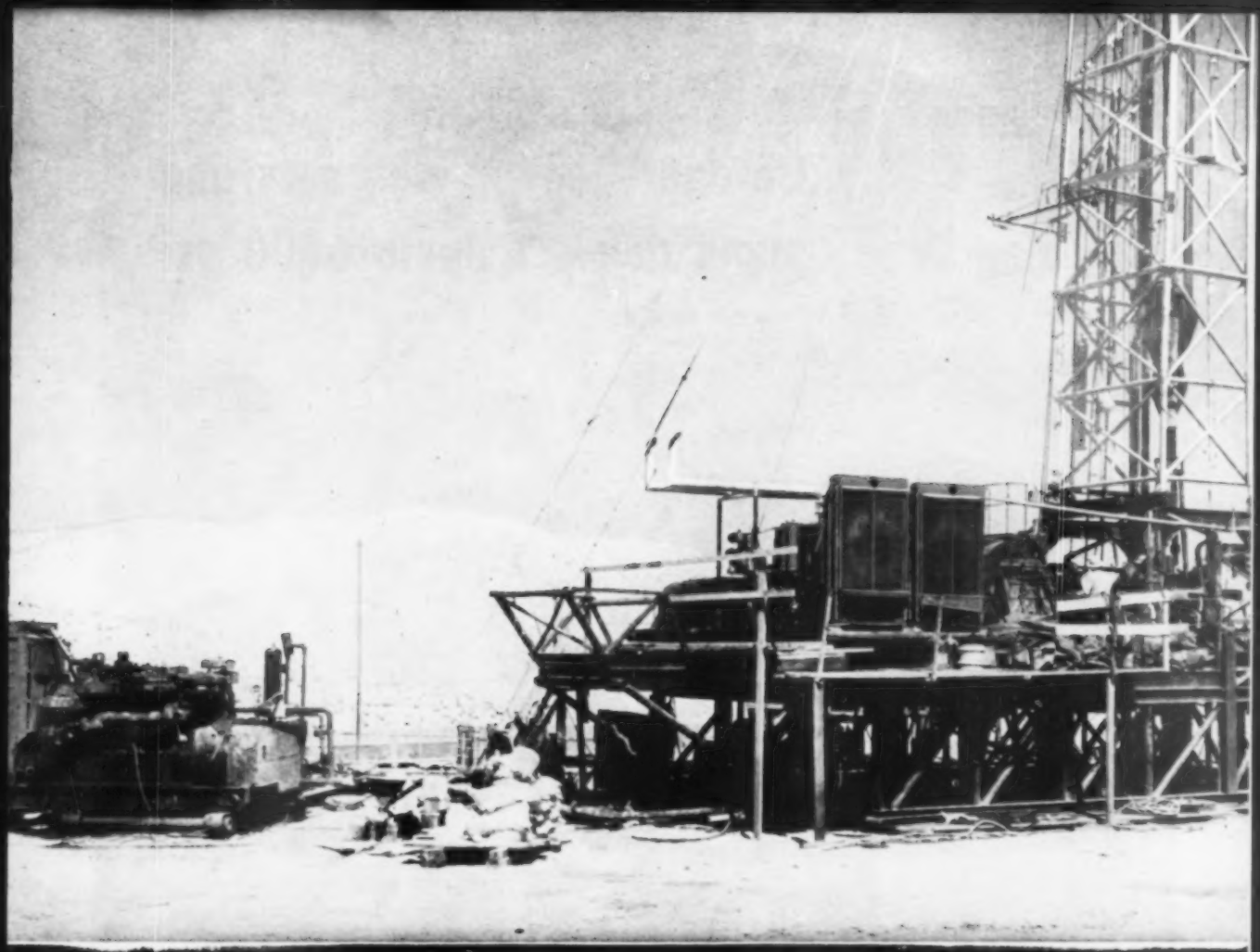
Send me your bulletin on SHALE BAN additive.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____



With 30 to 50 percent fewer moving parts... Allis-Chalmers diesel engines make more hole

THERE IS UNUSUAL SIMPLICITY in Allis-Chalmers engines. The 1879 diesels shown working above, for instance, *have 30 to 50 percent fewer wearing parts than competitive engines!*

THAT MEANS LESS WEAR . . . LESS THAT CAN GO WRONG when parts are fewer and stronger. Your equipment keeps working; you make more hole.

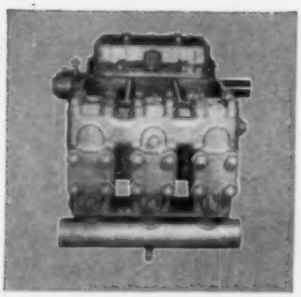
MORE POWER GOES TO WORK with Allis-Chalmers engines — not only because there are fewer moving parts, but because more efficient combustion means maximum power from the fuel.

You can have this simplicity, economy and durability in Allis-Chalmers engines of *any* size or type, 9 to 516 hp — *any* fuel, LP or natural gas, gasoline or diesel — for *any* application. See your Allis-Chalmers dealer for full information. Allis-Chalmers, Buda Division, Milwaukee 1, Wisconsin. BO-6

ALLIS-CHALMERS *Engineering in Action*

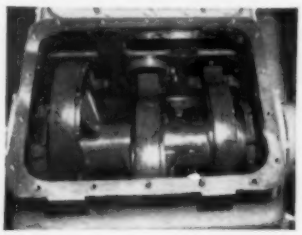
NEW Gardner-Denver well servicing pump delivers up to 6000 psi

New Gardner-Denver PE-5 single-acting triplex plunger pump for oil well servicing. Length, 69¼"; width, 47"; weight, 2990 lb. Maximum ratings on intermittent service: 130 bhp, 290 rpm, 1336 gpm, 1430 psi. Plunger diameters from 3" to 1¾" give a range to 32 gpm at 6000 psi.

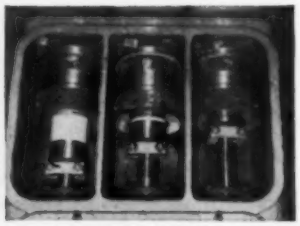


One-piece cast steel fluid end withstands peak loads. Valves individually accessible. Suction and discharge connections made from either or both sides.

Mounted positive oil pump driven directly from eccentric shaft assures lubrication to power end parts even at reduced speeds.



Exclusive Gardner-Denver eccentric drive, including one-piece connecting rods with bronze liners and pin bushings, helps eliminate major source of failures.



Hardened steel, ceramic, and special service plungers are available. Complete plunger and stuffing box assembly can be removed and repacked as a unit.

This new heavy-duty pump is built by Gardner-Denver especially to meet oil well servicing requirements. It has power and dependability to pay off for you. It's now in production. For details and prices, consult your distributor or the Gardner-Denver oil field office near you.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy Illinois—Gardner-Denver Export Division, 233 Broadway, New York 7, N. Y. In Canada: Gardner-Denver Company (Canada) Ltd., Toronto 16, Ontario.

Oil Field Offices: Dallas, Houston, Tulsa, St. Louis, Los Angeles, New York, Pittsburgh, Denver, New Orleans, San Francisco, Kansas City, Edmonton, Winnipeg.

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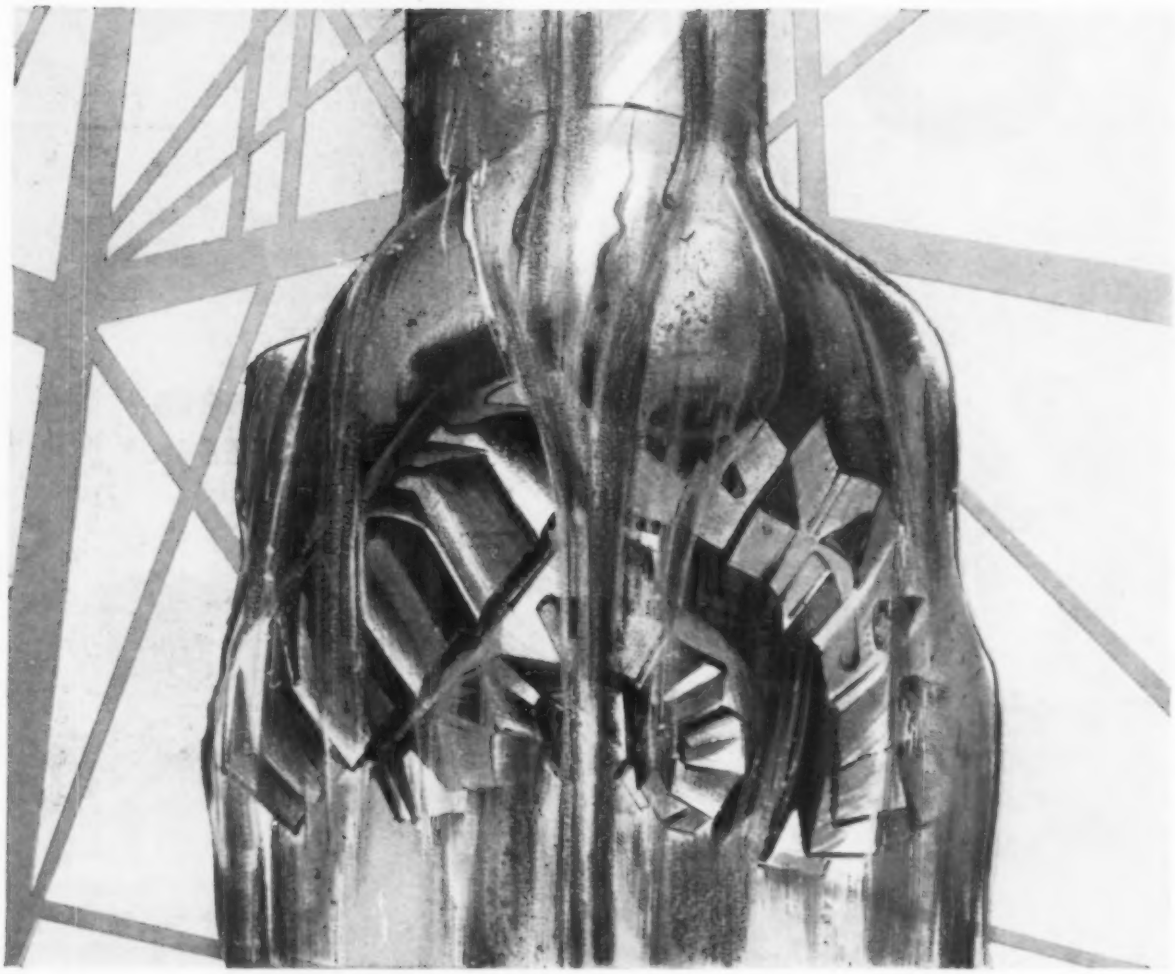

The biggest cuttings are in the cost with Du Pont CMC in drilling muds

More and more inshore *and* offshore operators are reporting substantial dollars-per-foot savings—some as high as 50% —in drilling costs since they have added Du Pont CMC to their mud.

The low viscosity of Du Pont CMC permits low fluid loss without excessive mud viscosity. Its resistance to thermal and bacterial degradation makes it ideally suited for high-temperature wells.

Add Du Pont CMC to sea-water muds —low- or high-pH fresh water muds— gyp-base muds—low- or high-lime muds —oil-emulsion muds. You can count on it for minimum fluid loss, even with reduced viscosity in some systems—*and at rock-bottom cost.* Ask for it from your local mud dealer or contact . . .

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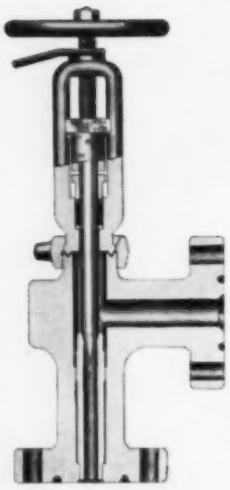
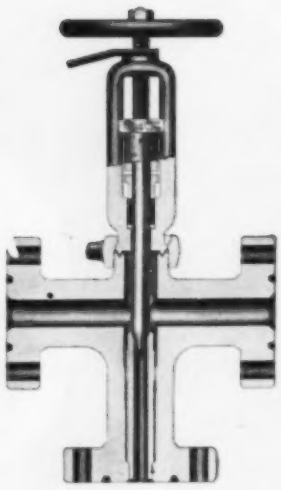


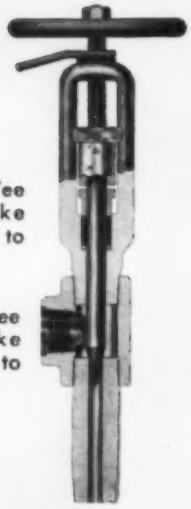
Type "N-2" Tee (Left) and Type "N-2" Cross (Right) adjustable chokes are suitable for pressures in excess of 3000 psi.

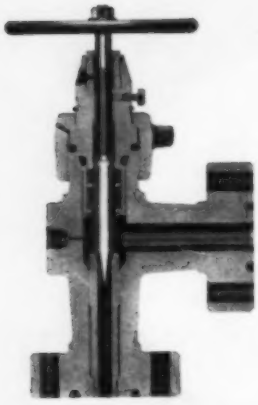


ADJUSTABLE CHOKES

Left: Type "N" Tee adjustable choke for pressures up to 3000 psi.

Right: Type "O" Tee adjustable choke for pressures up to 1500 psi.





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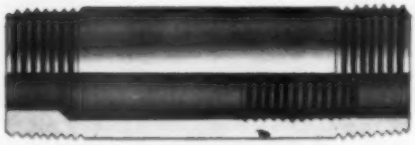
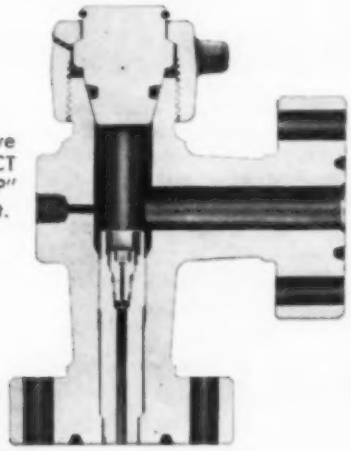
OCT Type "FC-140"
Cage nipple and
flow bean.





Type PC Positive
choke with OCT
Type "FC-142-P"
Proration insert.

OCT Type
"FC-142-P"
Proration
insert.

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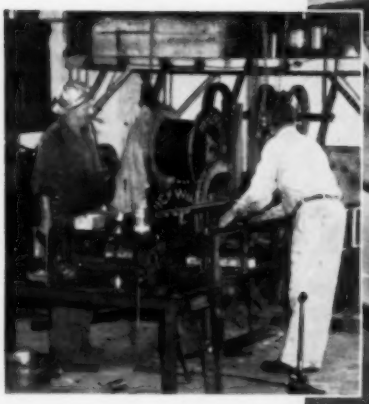

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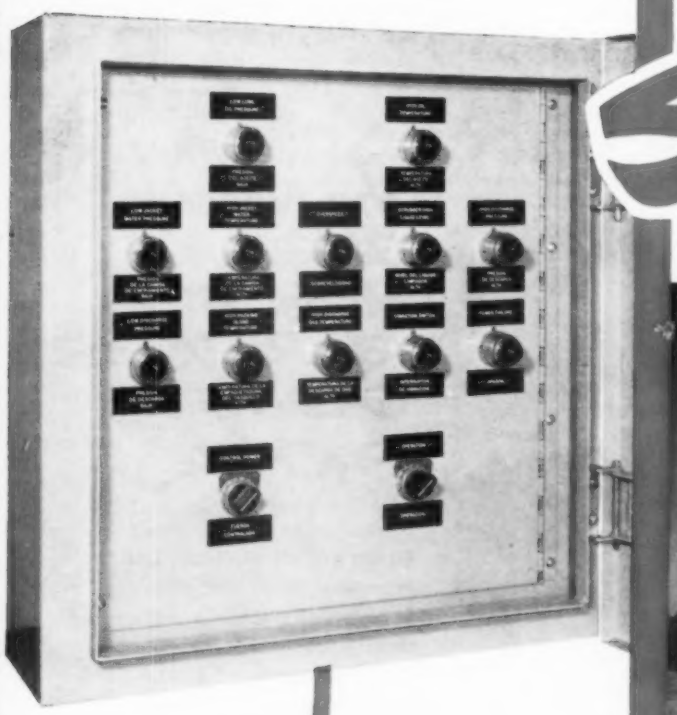

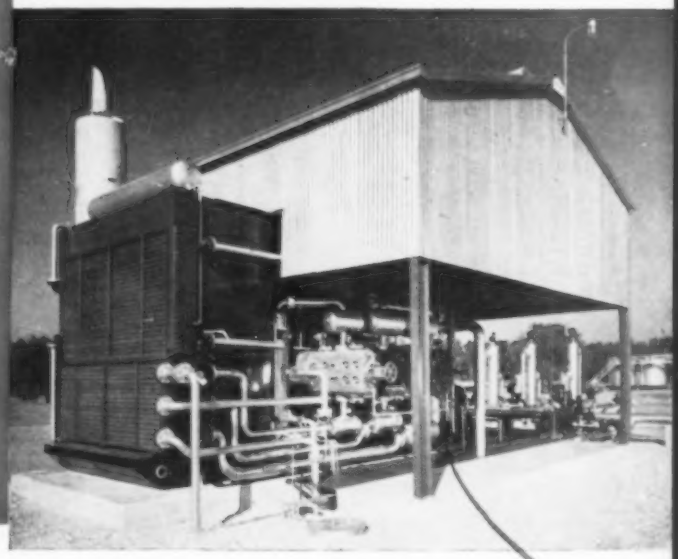

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Venezuela

Is Divided Into Three Basins

All three have been invaded by oil explorers, who found large production and great potential. The sub-surface has barely been scratched

Dr. Guillermo Zuloaga

THERE are three main distinct petroliferous basins in Venezuela: the Maracaibo Basin, the Orinoco Basin and the Apure-Barinas Basin. (See Fig. 1). They are of roughly equal size, some 20 million acres each. A fourth basin, the Tuy-Cariaco, is mostly covered by the sea and is practically unexplored by the drill.

Maracaibo Basin

By far the most important from the point of view of production and reserves is Maracaibo Basin. By the end of 1956 it had produced 7.3 billion bbl of oil, and proved reserves totaled 11.4 billion bbl.

Geologically, the Maracaibo Basin (See Fig. 2) is an ideal example of a geosynclinical basin of sedimentation. Almost completely surrounded by mountains, the basin has been slowly sinking and simultaneously accumulating a tremendous volume of sediments, while mountains that border it have been slowly rising.

Center of the basin is Lake Maracaibo, underlain by a thickness of some 16,000 ft of sediment, while the snow-covered peaks of the Sierra Nevada de Mérida on the southeast have an equal elevation. From the mountains, streams bring down to the lake silts and sand which would soon fill it, were the bottom not subsiding at about the same rate that the sediments are being deposited. As the mountains have risen, the area of the lake has become smaller, and its shores have become exposed; thus subject to erosion and to the analytical eye of the geologist.

Three main units of oil-bearing rocks underlie the surface of Maracaibo Basin. Lying on older and altered rocks are Cretaceous formations: Sandstones, limestones and shales, some 6000 ft thick. Above these, with only minor unconformity, Eocene rocks – mostly sands and silts – were laid down. Later, after erosion and with major unconformity, Miocene sands and shales were deposited. Prolific production has been found in the rocks of each of the three: Cretaceous, Eocene, and Miocene. That of the Miocene, the shallowest formation, was found first; later, those of the Eocene and Cretaceous.

All maps and geology columns courtesy of Creole Petroleum Corporation.

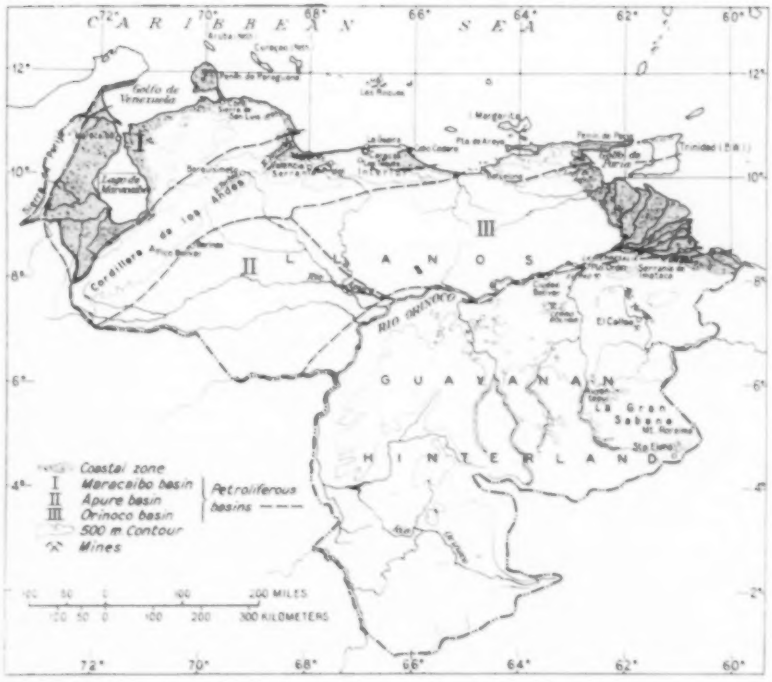


FIG. 1. Physiographic regions and petroliferous basins of Venezuela.

With the exception of a few small fields southwest of lake, and several minor fields to the northeast in Falcon, including the Cumarebo field, the producing fields of the lake basin are restricted to a broad belt, trending northwest from the Motatán field toward Maracaibo and beyond, and ending with the Mara field in the north. This is a remarkable trend; all the really large fields of the basin, whether in the Miocene, Eocene, or Cretaceous rocks, fall within it. It may be divided into two parts: The Bolívar Coastal field on the northern border and Mara districts on the northwest.

1. **Bolívar Coastal Field.**

In early days it was not realized that many of the fields along the shore of Lake Maracaibo in the District of Bolívar, State of Zulia, would eventually join, and each was given a name — La Rosa, Tía Juana, Lagunillas, Bachaquero, etc. Today these fields form a part of what is known as the

Bolívar Coastal field, which boasts a larger daily production potential than any other single oilfield in the world. (See Fig. 3 and Table 1).

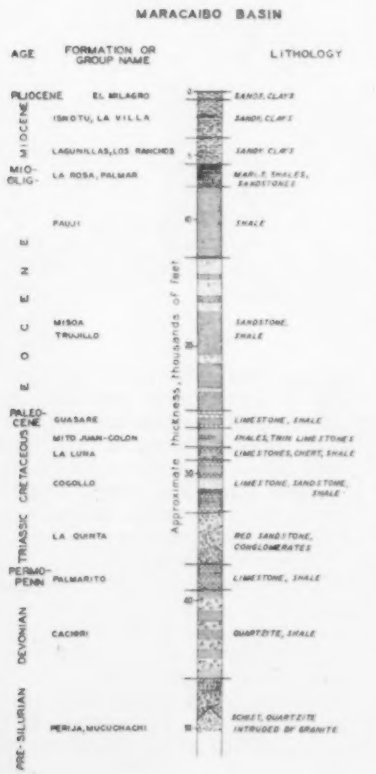
Bolívar Coastal field, on the northeastern flank of the Maracaibo Basin, extends over an area encompassing the eastern shore of Lake Maracaibo for some 54 miles from northwest to southeast, the width varying considerably and reaching a maximum of 25 miles. The discovery well, Santa Bárbara No. 2, drilled by a subsidiary of Royal Dutch-Shell, was completed in 1917 as a small producer from the Santa Bárbara sand, but not until five years later, December 14, 1922, when the Shell well R-4 blew out, making an estimated 100,000 bbl of heavy oil per day, was the stimulus provided for development of this large and tremendously rich oil-bearing area. After more than 35 years of development, the limits of the productive area are not yet fully outlined.

Shell holds all the land concessions in the area, and its original land holdings were subsequently expanded by the acquisition of several large lake concessions. The Mene Grande Oil Company, an affiliate of Gulf Oil Corporation, holds a number of concessions which lie in the lake. Creole Petroleum Corporation concessions also lie wholly within the lake.

In 1956 the Venezuelan government invited bids on a series of new concessions, the first offered since 1945. These concessions were granted in Lake Maracaibo and along the nation's frontier with Colombia. Six companies not operating in Venezuela at the time concessions were offered were among nine successful bidders who obtained the first new concessions in the lake.

Within the productive area, the drill has penetrated formations ranging in age from Recent to Basement. There are several unconformities within the section penetrated in the Bolívar Coastal field, the most pronounced being that at the top of the Eocene. Approximate maximum thickness of various formations making up the section are as follows:

Formation	Age	Thickness-Ft
Sediments	Recent	80
El Milagro	Pleistocene	2,100
La Puerta	Miocene	2,200
Lagunillas	Miocene	550
Icotea	Oligocene	460
Ambrosio	Eocene	360
Faujf	Eocene	6,200
Misoa	Eocene	10,000
Guasare	Paleocene	429
Mito Juan	Cretaceous	172
Colon Shale	Cretaceous	1,124
Socuy Member of Colon	Cretaceous	63
La Luna	Cretaceous	237
Capacho	Cretaceous	481
Apón	Cretaceous	370



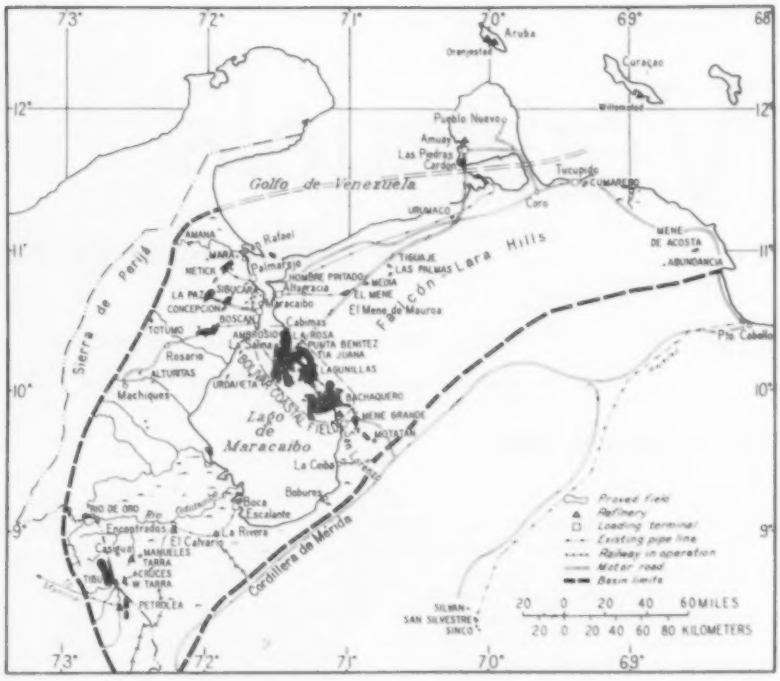


FIG. 2. Maracaibo petroliferous basin: Oilfields and facilities at beginning of 1957. Names of oilfields are in capitals. Size of fields has been exaggerated about two-fold. Largest pipeline shown, that from La Rosa to Amuay, has a daily capacity of 520,000 bbl.

TABLE 1.

	Year Production Began	Cumulative Production to Jan. 1, 1957 (Million bbl)	1956 Average Production B/D
MARACAIBO BASIN			
Bolívar Coastal fields	1917	5,748.1	1.408,743
Maracaibo-Mara fields	1922	882.4	252,732
Northeastern fields	1921	89.1	6,557
Southeastern fields	1914	456.6	42,350
Southwestern fields	1916	159.6	20.219
TOTAL-MARACAIBO BASIN		7,335.8	1,730,601
BARINAS-APURE BASIN		.6	546
ORINOCO BASIN			
Quiriquire-Jusepín-San Joaquín trend	1924	1,080.3	189,071
Tucupita-Temblador Oficina trend	1933	1,262.4	469,672
Las Mercedes-Tucupido trend	1943	124.0	42,896
Scattered fields	1914	52.4	18,033
TOTAL-ORINOCO BASIN		2,519.1	719,672
TOTAL VENEZUELA:		9,855.5	2,450,819

The Author

Dr. Guillermo Zuloaga is a member of the board of directors of Creole Petroleum Corporation and one of the most prominent men of the Venezuelan oil industry. A native of Caracas, he was graduated from that city's Central University in 1924 and then pursued his studies at Massachusetts Institute of Technology, where he received a PhD in geology.
Prior to joining Creole in 1939, he practiced his profession of geology and also served as Venezuela's first General Technical Inspector of Hydrocarbons. He was the founder of this service and was one of the first members of the corps of technicians built up by the Venezuelan government to handle its close relations with the private oil companies.
In addition to his attributes as a leader of the Venezuelan oil industry, Dr. Zuloaga is a noted natural scientist and author. He is a member of the Venezuelan Society of National Sciences; of the Venezuelan Academy of Physical Mathematical and Natural Sciences; of the Geological Society of America; of the Society of Economic Geologists, and of the American Association of Petroleum Geologists.

Geologically, the Miocene accumulation of the Bolívar Coastal field is made up of stratigraphic traps. In the underlying Eocene beds the accumulations are both structural and stratigraphic. The geologic structure of the Miocene is essentially monoclinal, the general dip being gently southwest toward the center of the basin. Post-Eocene sediments dip 2° to 10° to the southwest, the essentially monoclinal structure being broken by several well defined faults. The underlying Eocene erosional surface also dips to the southwest but Eocene beds themselves were folded and faulted before subjected to truncation. These disturbances present a complex subsurface problem in development of Eocene reservoirs.

Surface of productive areas consists principally of weathered sands and clays of Quaternary and late Tertiary age; east of Lagunillas and north of La Rosa, oil and asphalt seeps occur. At one place or another within the productive area of the Bolívar Coastal field, the Isnotu, Lagunillas, La Rosa, Icotea, Paují and Misoa formations have been found commercially productive, but by far the largest volume of oil to date has come from Lagunillas and La Rosa sands.

Production from Eocene sandstones has steadily increased during recent years. Eocene prospects first began to receive serious consideration in the early 1940's. This early Eocene drilling was confined to sands of the Misoa formation and was highly successful, establishing prolific production from well developed sandstones. In 1947 Shell began drilling in its central lake acreage with the result that large volume production was established from sands in the Trujillo formation. Production from these older Eocene sandstones has become a major factor in total Bolívar Coastal field production.

Although exploration drilling in the Bolívar Coastal field for Cretaceous production began 12 years ago, commercial production has not yet been established.

Accumulations of oil and gas in post-Eocene sediments are very largely in stratigraphic traps formed by the up-dip pinch-out of Miocene sands, or by sealing of these sands at their outcrops by tars and asphalts. Local structure plays a minor role; Icotea sand (Oligocene) is found only in local lows of the Eocene erosion surface, and thus also contains only stratigraphic accumulations. In the underlying Eocene beds accumulations are probably both structural and stratigraphic.

Oil produced in Bolívar Coastal field varies in gravity from 11 to 41 deg API. It is of asphaltic base with a wide range of characteristics, and is segregated into several grades. At the close of 1956, Creole's total daily production, 877,697 bbl was being segregated as shown in Table 2.

Near the southeast corner of the Bolívar Coastal field trend is found Mene Grande field, discovered by Shell in 1914 and the first commercial

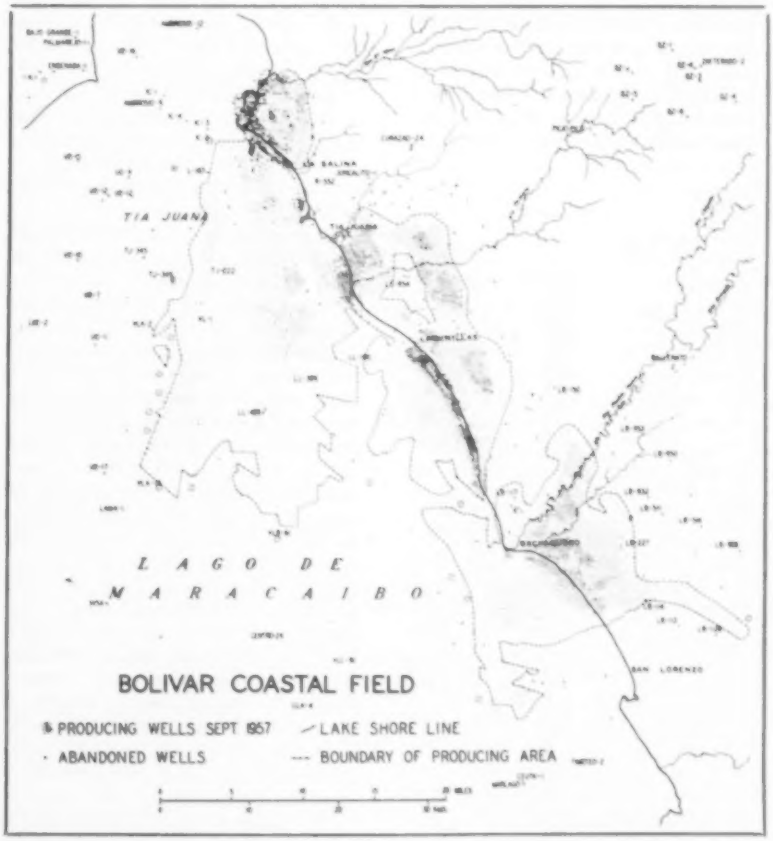


FIG. 3. Part of Bolivar Coastal field. Discovered in 1917, it has since been extended to a proved area of 54 miles from northwest to southeast, with a width that reaches a maximum of 25 miles. It now has an average daily production of 1,730,600 bbl and is one of the world's largest and most prolific fields.

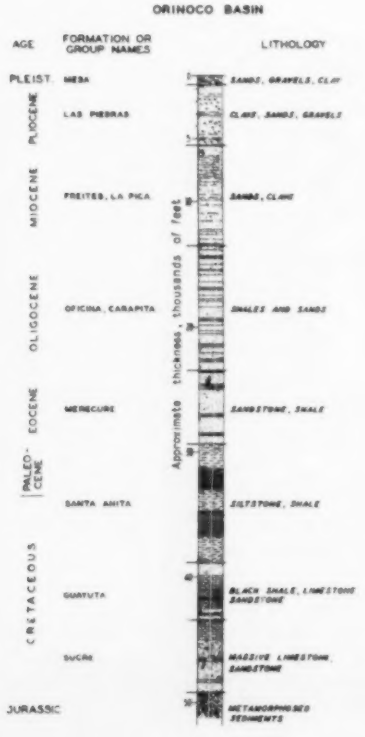
Table 2

TYPE OF CRUDE	GRADE	PRODUCTION B/D
La Rosa	Medium (21.3 API)	8,582
Punta Benítez (Miocene)	Medium (23.3 API)	58,996
PB-101 (Miocene)	Medium (25.2 API)	9,131
TJ-102 (Miocene)	Medium (24.7 API)	128,727
LL-370 (Eocene)	Medium (25.6 API)	88,737
North LL-370 (Eocene)	Medium (24.6 API)	52,797
LL-453 (Eocene)	Medium (27.1 API)	170,939
TJ-Heavy (Miocene)	Heavy (18.6 API)	20,409
TJ-Heavy (Eocene)	Medium (22.4 API)	1,560
TJ-319 (Eocene)	Medium (25.9 API)	40,018
TJ-319 (Miocene)	Medium (27.1 API)	1,993
LL-652 (Eocene)	Light (35 API)	9,663
LL-261 (BA)	Heavy (17.1 API)	1,309
LL-Heavy	Heavy (17.9 API)	54,345
Bachaquero heavy	Heavy (17.1 API)	194,722
South TJ-medium (BA)	Heavy (17.1 API)	35,769

field in Venezuela. At the end of 1956, its cumulative production was 453.7 million bbl, and after 42 years of operation it was still, at that time, producing about 37,800 bbl a day.

2. Fields in Urdaneta, Maracaibo and Mara districts, State of Zulia.

In August 1944, Shell Caribbean Company completed its well P-68 in Cretaceous limestone within the area of the older La Paz field, producing at the rate of over 5000 bbl a day. This well was the first large volume producer from beds below the Tertiary in this area. In 1945 well DM-2 in the Mara area was completed as the discovery well of the Mara field in the same trend as the La Paz field. Concepción and Sibucara, of less importance than La Paz and Mara, are also fields in this general area which have



Cretaceous production. Sibucara is of special interest because it has the deepest production in Venezuela, averaging approximately 14,000 ft. In all, 449 wells had been completed through 1956 among the La Paz (Shell), the Mara (Shell-Creole-Texas), the Concepción (Shell) and the Sibucara (Shell) fields, and they have a daily potential of 205,000 bbl.

In Northwestern Zulia area there is a limestone section about 1800 ft thick between Upper Cretaceous Colon shales and the underlying basement rocks. This limestone is composed from top to bottom of: (1) a basal member of the Colon formation (100 ft); (2) Luna formation (300 ft); (3) Cogollo limestone (1400 ft). All portions of this section have been found productive. In 1953 production was obtained in a Shell well from the fractured basement granites of this area.

These, and more recent Cretaceous discoveries, are of major importance, not only because of the volume and quality of the oil, but also because they open greater possibilities for further developments in the Cretaceous elsewhere in Venezuela. Although it is rarely possible to make direct observations on the exact nature of Cretaceous pay zones, it is believed that production is almost entirely from fractures in dense limestone. All portions of the section, from the top of the limestone to the beds overlying basement, are known to be productive.

Present Cretaceous fields lie in the western part of Maracaibo Basin, approaching its western margin, which is marked by the Perijá Mountains along the international boundary between Venezuela and Colombia. But it is quite possible that Cretaceous rocks underlying the major part of the entire Maracaibo Basin may show important local accumulations of oil commercially significant in volume. Presence of these rocks beneath Lake Maracaibo has already been noted.

In addition to La Paz, Mara, Concepción and Sibucara fields in Northwestern Zulia, an important discovery was made in 1946 by Richmond, in Paleocene-Eocene sands at Boscán in Urdaneta district. By the end of 1956, this field had produced a total of 76.8 million bbl and had become the third largest field in Venezuela, with a daily average production of 91,000 bbl. Boscán oil is very heavy (slightly over 10 API) and very viscous, and as a result presents many production problems. Similar oil in still undetermined volumes has been found by Creole in the Urdaneta field in the northwestern part of Lake Maracaibo.

Oil produced in Maracaibo Basin is transported in two ways: By pipeline to the Paraguaná peninsula where the two major refineries are located, or by tanker for overseas destinations. At the refineries, the crude is either processed into refined products and then shipped out by tanker, or it is taken directly from the pipeline to storage tanks and then transferred to tankers.

In 1956, approximately 820,000 bbl a day were transported from Maracaibo Basin by pipeline and 835,000 bbl a day moved out by tanker. Ports on the Paraguaná peninsula handled approximately 874,000 bbl a day.

A recent development of far-reaching importance, not only for the transportation of oil but for the economy of the entire Maracaibo Basin as well, has been the dredging of the bar across the entrance to Lake Maracaibo. This project is one of the major public works carried out by the Venezuelan Government to date. Requiring three years to complete, it was financed by a bond issue in which several oil companies participated.

The bar formerly restricted passage through the mouth of the lake to partially-loaded T-2 tankers of 17,000 tons. The new 21-mile channel, dredged to a depth of 35 ft, permits fully loaded 35,000-ton tankers to navigate through the entrance. Oil companies operating in the lake are expanding their terminal and handling facilities to take advanage of this development.

Another development of major interest in recent years has been construction of large conservation plants in Lake Maracaibo. These plants receive gas that is separated from the crude oil, compress it under high pressure, and then return it to the producing reservoirs with a two-fold purpose: To increase oil recovery through maintenance of pressure in the reservoir, by means of the gas injected, and to conserve the gas itself, which remains in the reservoir for future use.

Orinoco Basin

The petroliferous Orinoco basin is second to Maracaibo Basin in produc-

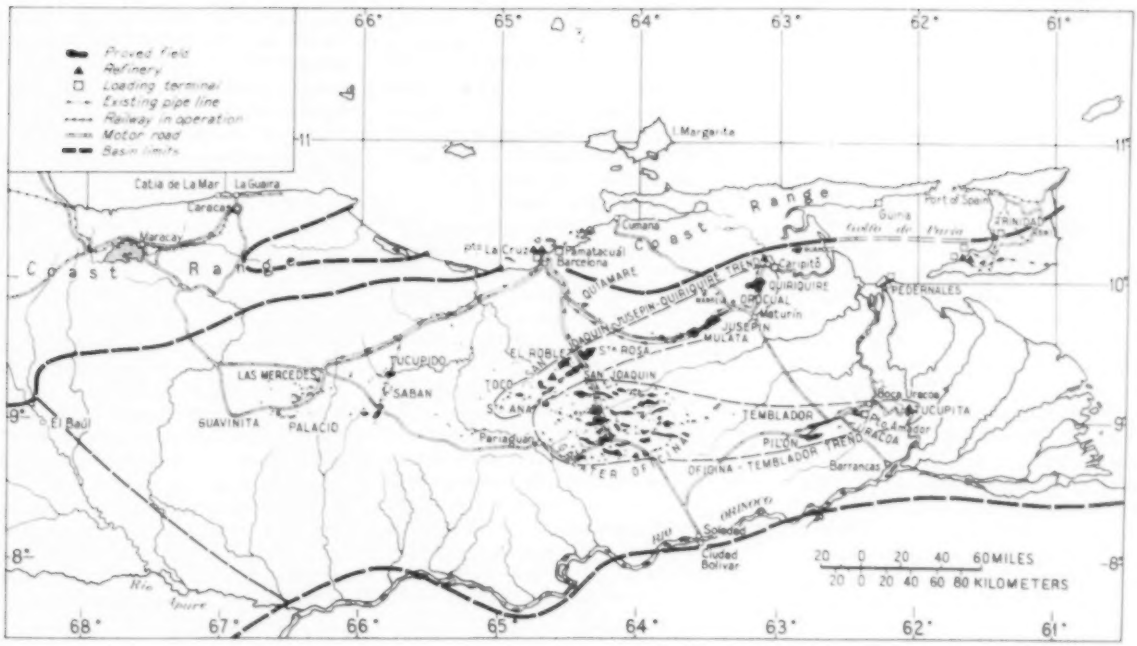


FIG. 4. Petroliferous basins of eastern Venezuela: Oilfields and facilities at beginning of 1957. Names of oilfields are in capitals and size of fields has been exaggerated about two-fold.

tion and reserves. From the beginning of production, over 2.5 billion bbl had been produced by the end of 1956. (See Table 1). The basin comprises the areas bounded on the north by the Coastal Range, on the south by Orinoco River, on the east by the Atlantic Ocean, and on the west by the El Baúl "high" in Cojedes, an eminence in the underlying basement and Paleozoic rocks which forms a saddle between the Orinoco Basin and the Apure-Barinas Basin, farther to the west. Since Mesozoic times, sediments have been deposited in the Orinoco Basin from the erosion of crystalline rocks in the Guayana shield to the south and of the metamorphic rocks in the rising Coastal Range to the north. A gradual tilting toward the east has taken place, deepening the basin in that direction.

The whole basin lies within the llanos. Flat plains and mesas of Recent sediments cover the older rocks, so that exploration for oil has been largely based on geophysics and drilling; stratigraphic studies have been restricted to the Coastal Range, where some of the formations outcrop.

As in Maracaibo Basin, the main oilfields of Orinoco Basin occur in three main trends, viz.: (1), The trend including Quiriquire field, the Greater Jusepin area, and the San Joaquín area; (2), the trend including Tucupita field, Temblador area and Greater Oficina area; and (3), the trend including Las Mercedes, Tucupido and neighboring fields in the west.

1. Quiriquire-Jusepin-Anaco Trend.

This trend is composed of three units: The Quiriquire field itself to the northeast, the Greater Jusepín area in the middle and San Joaquin-Santa Rosa-Roblé area to the southwest.

Quiriquire field, which is situated some 12 miles due north of Maturín, capital of the State of Monagas, was the first commercially profitable oilfield discovered in Eastern Venezuela, and it is still the most productive. By the end of 1956, it had produced 502.2 million bbl of oil, or nearly 20 percent of the total recovered from the Orinoco Basin, and it was then producing at the rate of 65,600 bbl a day. The field was discovered in 1928 by Quiriquire-2, formerly called Moneb-1, which was drilled down-dip from prominent oil seeps.

Structurally, Quiriquire is a monocline dipping to the southeast at approximately 15°. The Miocene-Pliocene Quiriquire formation, which furnishes the oil production of the field, is an interfingered, overlapping, alluvial fan series, for the most part continental in origin and deposited unconformably on truncated, folded beds ranging in age from Cretaceous to Miocene. This section consists of clays interbedded with unsorted sands, gravels and boulders. Rapid lateral changes in deposition make sand-for-sand correlation within the Quiriquire formation virtually impossible.

The area of petroleum accumulation is an irregular oval about nine by five and three-fourths miles in extent, with the maximum thickness of net oil sand in the central part of the field (700 ft), and an average of 194 ft per well.

Major production zones in the Quiriquire at present are basal members, Zeta, Eta, and Theta, which essentially contain heavy oil, but have numerous beds saturated with water and noncommercial heavy crudes. Members above Zeta are generally productive along the northern edge of the structure, but to the south (down-dip) they largely contain water and tar oil.

The irregularly varying gravity of the oil (9 to 28 deg API) in the productive section may be attributed to the lithology of the reservoir and mode of accumulation. The crude produced is relatively heavy, its average gravity being 16.4 deg API. Sulfur content is 1.18 percent. Quiriquire crude is best suited for producing aviation gasoline, normal and cracked motor gasoline, hydrogenation stocks, marine diesel fuel, and high quality bunker fuels. Deep drilling under Quiriquire has found only gas in Eocene beds.

The Greater Jusepín field is about 18 miles due west of Maturín and was discovered by the successful completion of Jusepín-1 on October 13, 1938. It had produced approximately three-fourths as much oil as the Quiriquire field — 369.8 million bbl — by the end of 1956, at which time its daily production was 57,000 bbl a day or about 9000 bbl a day less than Quiriquire.

Although different "field" names are

used by the various operators of the concessions (i.e., Northeast Extension, Jusepín Proper, Mulata, Santa Bárbara, Travieso, etc.), these names are indicative only of concession ownership, and the productive area may be considered as one large field which trends roughly N 60° E for 27 miles and obtains a maximum width of four and one-half miles.

Two formations produce in Greater Jusepín field. The lower of these is the Oligocene, so-called N-15 sand section, which produces in the Northeast Extension, a narrow accumulation on the northeastern end of the field. These sands are fine to very coarse grained, and highly lenticular. The upper producing formation, and the most important, is the La Pica, of Middle Miocene age. This formation pinches out rapidly to the north and the sands shale out to the east, conditions which made for a stratigraphic trap. The La Pica sands are very fine grained and shaley.

The primary reason for the accumulation of oil and gas in the Greater Jusepín field is stratigraphic. Structural features, such as noses and normal faults (the latter are very numerous) play a secondary role in the accumulation.

The Jusepín crude has a gravity range of 22 to 36 deg API, with an average of 31 deg API. It exhibits moderate sulfur content and is suited for the production of average quality motor fuels, various grades of gas oils, diesel oil and bunker fuels.

The Anaco area, in the southwestern part of the trend, had, by the end of 1956, yielded 210.3 million bbl of oil since the beginning of production in 1937, and it was producing at the rate of 94,678 bbl a day at the end of last year. Of this production, the greater part was coming from the Santa Rosa and Santa Ana fields.

The Anaco area is composed of the Toco, Santa Ana, San Joaquín, Santa Rosa, San Roque and El Roble fields. The first four are located in a series of elongated domes along a regional uplift which trends in a northeast direction across central Anzoátegui. All these domes are asymmetric, the northwest flanks having a relatively gentle dip (10°), while the dips on the southeast flanks range from 15° in the upper beds to overthrust lower in the section. This thrust fault is known as the Anaco Thrust.Various domes are separated by saddles or by sharp synclines which are probably faulted. The San Roque and El Roble fields are broad, gentle domes (average dips 3°) developed on the northwest flank of the Toco to Santa Rosa series of "highs" and separated from that feature by normal faulting.

Oil and gas accumulations in the Anaco area are confined to the Mio-Oligocene and Oficina and Oligocene Merecure formations. The former is a thick section of interbedded grey shales, thin lignite beds and relatively thin sandstone beds. Twenty-six Oficina formation sands are productive at one place or another in the area. The Merecure formation, which underlies the Oficina conformably, is a section of very hard, generally fine grained and often thick-bedded sandstones, interbedded with thin layers of hard black shale. At the present time, the Oficina formation furnishes more oil production than the Merecure in the San Roque, El Roble, San Joaquín, and Santa Rosa fields; the opposite is true in Toco and Santa Ana fields.

Accumulations of oil and gas are generally confined to the area of closure under each of the domes. Most of the producing Oficina sands had an original gas cap, and those that did not have such caps originally developed them with production.

Throughout the area the Merecure formation contains large reserves of gas and condensate.

Crude from the Anaco fields is noted for high wax content. Gravity of the oil produced ranges from 34 to 45 deg API.

2. Tucupita-Temblador-Greater Oficina Trend.

The Temblador area, in south-central Monagas, embraces several separate fields, but only the Temblador field was producing in 1956. The area's total production at the end of 1956 was slightly less than 80 million bbl, and the current rate of production is 13,500 bbl per day.

Surface of the entire area is covered by the Quaternary Mesa formation. The discovery well of the area, Temblador-1, was located in 1936 on the north (basinward) side of a major regional fault (Temblador fault) revealed by a seismograph survey. The Temblador area is high on the southern limb of the Maturín Basin, a part of the eastern Venezuelan geosyncline and structural basin. Structurally, the area is a homocline dipping northward at about two degrees and broken by a number of regional ENE-WSW normal faults, with smaller branch cross faults trending generally NW-SE. These two sets of faults are of primary economic importance, because, in the absence of closed folds, they provided the necessary traps for oil and gas migrating updip from the central part of the basin.

The stratigraphic section, encountered in the area consists of 300 to 500 ft of Quaternary sediments (Mesa formation), underlain unconformably on the Miocene Freites formation, 1900 ft thick. The Mio-Oligocene Oficina formation, about 500 ft thick, unconformably underlies the Freites, and is in turn unconformably underlain by about 600 to 700 ft of Cretaceous Temblador formation, which rests on the igneous-metamorphic Basement Complex (Guayanan shield). The formation thicknesses given apply to the Temblador field; in the Pilón and Uracoa fields the thicknesses are somewhat reduced, because of the more shoreward (southerly) position of these fields.

Oil-bearing reservoir beds of the area are confined to the Oficina sands. Upper Oficina reservoirs consist of soft to hard, fine to medium-grained sands, interbedded with thin shales and containing some thin coal seams. The lower productive sands consist essentially of soft, fine to coarse-grained arkose, interbedded with hard shales.

The Temblador field is producing under an active water drive, which, combined with the good porosities and permeabilities in the sands, is expected to result in a high ultimate recovery of oil. However, salt water is intimately associated with the oil, and has, of necessity, been produced with it, almost from the beginning. This contamination with salt requires an elaborate dewatering and desalting operation.

Oil produced from the Pilón and Uracoa fields is similar to but heavier than that from the Temblador field. The Temblador crude, which is of naphthenic base with a moderate sulfur content, is best suited to the manufacture of aviation and motor gasolines, gas oils and bunker fuels.

The Greater Oficina area in south-central Anzoátegui embraces a number of oil fields in addition to the Oficina field proper, which is the oldest of these fields. The area has produced almost 1.2 billion bbl since the beginning of production in 1937, and at the end of 1956 the average rate of output was 495,000 bbl per day. The discovery well of the area, Oficina No. 1, was located at a point where torsion balance and refraction seismograph data showed a structural disturbance in the general northward dip.

Bulk of the concessions in the area are held by Mene Grande Oil Company, C. A., or jointly by Mene and Creole. Socony-Mobil, Texas, Sinclair, and Atlantic have smaller holdings.

The Greater Oficina fields are located on the southern limb of the eastern Venezuelan geosyncline (the Orinoco Basin). Outcropping in the area are the flat Quaternary Mesa formation and the Pliocene-Upper Miocene Sacacual group (Las Piedras and Algarrobo formations). These are underlain unconformably by the Miocene Freites formation and the Mio-Oligocene Oficina formation neither of which outcrops. The latter, which is up

to 5000 ft thick, lies unconformably on the Cretaceous Temblador formation, which in turn rests unconformably on the igneous-metamorphic basement (Guayana shield).

Axis of the southern limb of the eastern Venezeulan structural basin trends east-northeast and dips gently in that direction. The prevailing northward dip is of two of four degrees, increasing gradually toward the axis of the basin. There are a few very gentle noses and depressions, but the characteristic and economically important structural feature of the area is an intricate fault pattern. The larger faults trend parallel to the axis of the basin and are invariably intersected by smaller faults trending northwest-southeast.

Early drilling in the Greater Oficina area was chiefly concentrated in the southern, relatively shallow part of the area (5000-10,000 ft). As these shallower fields were developed, exploration drilling was gradually shifted to the deeper part of the basin to the north. During the last two years, several major fields have been discovered whose principal reservoirs lie between 10,000 and 14,000 ft in depth. New drilling and completion techniques permit the drilling of these deep wells in from 40 to 60 days. At present there are 119 fields in an area 80 miles in length by 40 miles in width. From the point of view of the territory it embraces, this is the largest producing area in Venezuela.

Accumulations of oil and gas in the Greater Oficina fields are found on the basinward (north) side of the longitudinal faults, lateral closure being provided by cross faults, or in some cases, by pinch-outs of the sand. The number of sands varies from 50 to 70 in different parts of the area, with the maximum number of productive sands in any one field being 47 (West Guara field). The large number of sands, coupled with the many faults and some sand pinch-outs, has resulted in some outstanding examples of multiple-reservoir fields in the area, the largest number of Oficina reservoirs in any one field being 100 (Oficina reservoir proper). Oil staining, but no production, has frequently been found in the sands of the underlying Temblador formation.

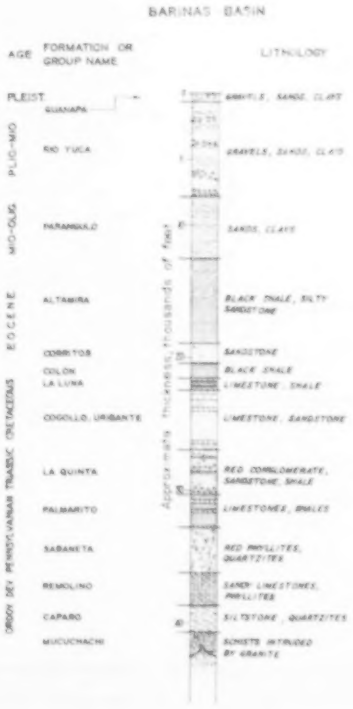
Reservoir sands, which range in thickness up to a little more than 100 ft, are soft to hard, compact, fairly clean, and of medium-grained texture. Porosities usually range from 12 to 25 percent, sometimes approaching 30 percent, and permeabilities usually range from 100 to 1000 millidarcies, occasionally reaching several thousand millidarcies. A few sands carry only gas. Many of the oil reservoirs have induced gas caps, with the oil columns varying in height up to 500 ft. Production depths vary from 4000 to 14,000 ft, and, because of the many reservoirs, dual completions are common.

The oil is usually of intermediate base, varying in gravity from 8 to 57 deg API, but no oil heavier than 10 deg API has been exploited. Pourpoints vary from below 50 F to 90 F, with the paraffin-wax content varying from 5 percent to more than 15 percent. The wax oils (more than 4 percent wax content) usually have a gravity lighter than 35 deg API. Sulfur content varies from less than .5 percent (lighter oils) through 1.2 percent (medium) to 2.3 percent (heavier).

3. Las Mercedes-Tucupido Trend.

Of the total of 124 million bbl produced in this area through 1956, from the beginning of production in 1945, 49 million bbl came from the Las Mercedes field, discovered in 1943. It was producing 17,000 bbl per day as of December 31, 1956. The Tucupido field, which began producing in 1945, had yielded 21.5 million bbl by the end of 1956 and was producing at the rate of 4000 bbl per day at that time. Production rate of the Palacio field, discovered in 1947, was 4600 bbl per day on that date. Two fields, Gavinita and Sabán, began a small production in 1948, and the Ruiz field, where production began in 1949, was producing 6800 bbl per day at December 31, 1956. These fields are all located in the State of Guárico in central Venezuela.

Oil produced in the Orinoco Basin is transported by pipeline to terminals for shipment as crude, or to refineries where it is processed and then shipped. A network of pipelines almost 1000 miles in length does this big job. The two principal ports from which crude and products are shipped are Puerto La Cruz on the Caribbean Coast and Caripito on the San Juan River, site of a Creole refinery that processes more than 60,000 bbl per day. In addition, crude and products are shipped from Tucupita on the Mánamo River, where Texas Petroleum Company has a small refinery, and from Boca Uracoa in the Pedernales region. These four ports in 1956 handled an average of 703,000 bbl daily in oil shipments.



Industrial and domestic markets for natural gas are now beginning to develop in Venezuela and a start has been made on the construction of pipelines to carry the gas to these markets. The two major existing lines were placed in operation in 1952, a short line was built in 1955, and the government has started right-of-way work and is already laying pipe on a 26-in. pipe line from Anaco to a point south of Caracas, a distance of 206 miles. This line will supply gas for domestic and industrial users in the Caracas area, and the government has indicated that it intends later to extend it westward to Morón, the site of the new petrochemical plant it is now building. Of the existing lines, one runs from the Anzoátegui area to Puerto La Cruz, and other from the Las Mercedes area to Caracas and La Guaira. A branch of the latter line extends west to Valencia, and it was to this line that the Government in 1955 built a short connecting line from Guacara to Morón.

The city of Maracaibo now is being supplied with gas, chiefly for industrial users but also for some domestic consumers, from the La Paz field.

Apure-Barinas Basin

Serious exploration in the Apure-Barinas Basin was not begun until 1947, and only one commercial field has been found in the area to date. Discovered in 1948 by Socony-Mobil, this is the Sinco-Silvestre field. By the end of 1956, Socony had completed 16 wells, and Sinclair Oil & Refining Company had completed 25. Average depth of these wells is 9800 ft and, after penetrating Miocene, Eocene, and Cretaceous rocks, most are in Basement.

A pipeline more than 200 miles in length runs from this area to Puerto Cabello to provide the crude from this field a deep water outlet.

Although relatively little exploratory drilling has been done in the Apure-Barinas Basin, the prospects of eventual establishment of a considerable amount of production from this area are thought to be good. ★ ★ ★

In Venezuela's Limon field, Mene Grande uses . . .

Depletion Calculations for Segregation Drive

Segregation effects in high-permeability or steep-dipping sands have a marked influence on the performance of a solution gas drive reservoir. Here's a method that takes into account these effects

ECONOMIC justification for a fluid injection project requires the prediction of future reservoir behavior under both primary and secondary recovery conditions. With the present tendency to commence injection very early in the life of a reservoir, the short producing history available is of little use in assessing the actual drive mechanism. This is especially the case where the reservoir oil is initially undersaturated.

In high-permeability or steep-dipping sands, with little or no aquifer water drive, the assumption of a simple solution gas drive below the bubble-point pressure may give a very misleading picture, due to the presence of segregation effects.

The following study of a particular reservoir is an example of the method now used by Mene Grande to take account of such effects.

T. A. O'Brien
Mene Grande Oil Company

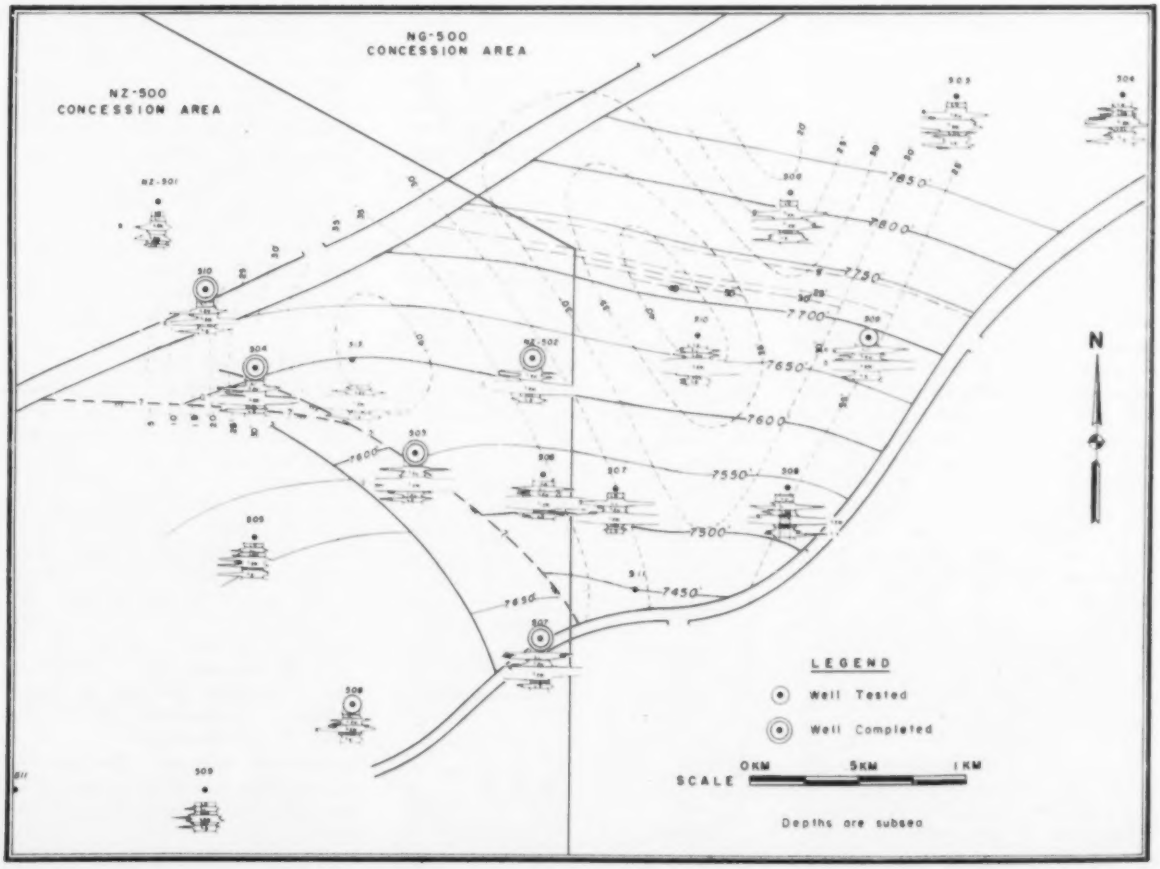


FIG. 1. **Structure, isopach and electric log** map for the L2m reservoir of the Limon field in eastern Venezuela.

The L2m Reservoir

The Limon field is located in the Greater Oficina area of Estado Anzoategui, Venezuela, and lies on the southern flank of the eastern Venezuelan geosyncline. The L2m sand is part of the Oficina formation of Oligocene-Miocene age, which consists of some 3200 ft of alternating sandstones and shales. Accumulation in the reservoir is controlled by updip and lateral fault traps with an aquifer downdip. Aquifer water drive is inhibited by a 200-ft column of tar oil at the oil-water interface. The reservoir oil was initially 850 psi undersaturated.

A combined structure-isopach and electric log map is shown in Fig. 1. General reservoir statistics are given in Table 1 and the PVT information in Fig. 2 and 3.

Total Reservoir Volume (Vp)

From the material balance for undersaturated oil:

$$V_p = \frac{N_p \overline{B}_o}{(P_i - P)\,(S_{oi} \cdot C_o + S_{wr} \cdot C_w + C_f} \text{ bbl} \quad . \quad . \quad (1)$$

Nomenclature is given at the end of the paper.

For stock tank oil production to date of 311,000 bbl, a corresponding reservoir pressure decline of 345 psi, average oil volume factor and compressibility from the PVT data, water and formation compressibilities from Hawkins[1] correlations and using an interstitial water saturation of 4 percent determined by the "restored state" method:

$$V_p = \frac{0.311 \times 10^6 \times 1.300}{345(0.96 \times 12.3 \times 10^{-6} + 0.04 \times 3.3 \times 10^{-6} + 3.5 \times 10^{-6})}$$
$$= 76.0 \text{ million bbl}$$

Stock Tank Oil Initially in Place (N)

Production between initial and bubble-point pressures, estimated by extrapolating the available reservoir pressure-production history, will be 0.9 million bbl. The stock tank oil initially in place is then:

$$N = \frac{V_p\,(1 - S_{wr})}{B_{ob}} + 0.9 \text{ bbl} \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$= \frac{76.0 \times 10^6 \times 0.96}{1.309} + 0.9$$
$$= 56.6 \text{ million bbl}$$

TABLE 1. Reservoir and Fluid Characteristics of the L2m Sand in the Limon Field in Eastern Venezuela.

RESERVOIR CHARACTERISTICS	
Datum level: subsea	7550 ft
Datum level: average subsurface	8170 ft
Average porosity	22.9%
Average homogeneous fluid permeability (K):	
horizontal	4.54 darcys
vertical	2.43 darcys
Interstitial water ('Restored-state' method)	4.0 %
Average reservoir temperature	230 F
Initial datum pressure	3320 psi
Sand surface area	997 acres
Formation compressibility[1]	3.5×10^{-6} v/v/psi
FLUID CHARACTERISTICS	
Average gravity	24.0 API
Bubble-point pressure at reservoir temperature	2470 psi
Solution gas-oil ratio at bubble point	484 cu ft/bbl
Oil formation volume factor at initial reservoir pressure	1.298 v/v
Oil formation volume factor at bubble-point pressure	1.309 v/v
Average compressibility of reservoir oil above bubble-point pressure	12.3×10^{-6} v/v/psi
Interstitial water compressibility[1]	3.3×10^{-6} v/v/psi

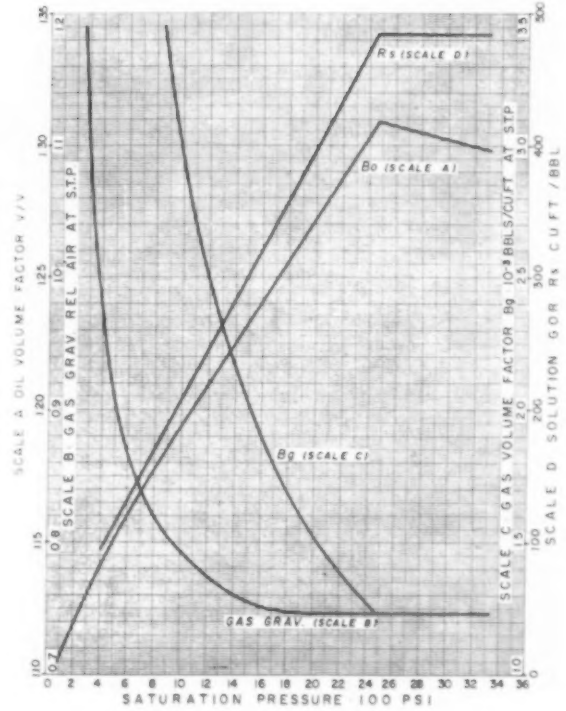

Rs (SCALE D)
Bo (SCALE A)
Bg (SCALE C)
GAS GRAV. (SCALE B)
SCALE A OIL VOLUME FACTOR V/V
SCALE B GAS GRAV REL AIR AT STP
SCALE C GAS VOLUME FACTOR Bg 10⁻³ BBLS/CUFT AT STP
SCALE D SOLUTION GOR Rs CUFT/BBL
SATURATION PRESSURE 100 PSI

FIG. 2. **Differential vaporization properties** at 230 F of undersaturated bottom-hole sample from Well NZ-502.

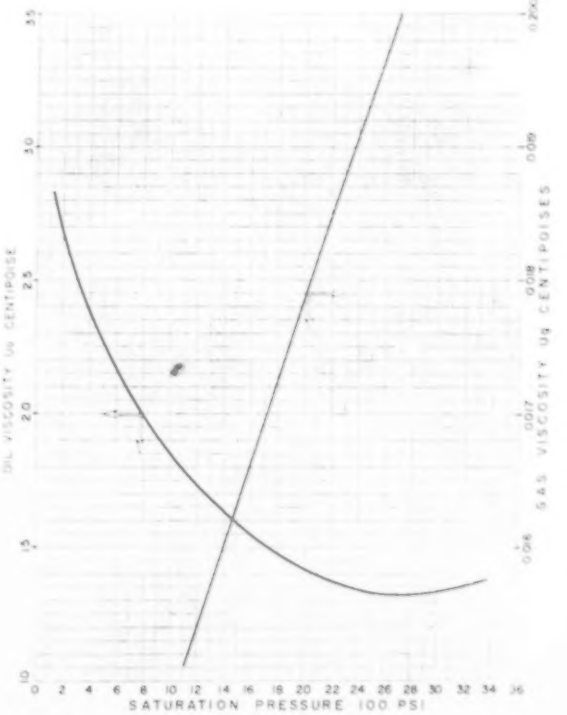


FIG. 3. **Viscosity analysis** at 230 F of undersaturated bottom-hole sample taken from Well NZ-502.

Pressure Depletion Below Bubble Point

The segregation rate is:

$$q_{oc} = 7.825 \times 10^{-3} \frac{A}{\bar{B}_o} (\bar{d}_o - \bar{d}_g) \left(\text{lesser of } \frac{\bar{K}_g}{\bar{U}_g} \text{ or } \frac{\bar{K}_o}{\bar{U}_o}\right) \sin \Theta \text{ bbl/day} \quad . \quad . \quad . \quad . \quad (3)$$

A is taken here as the area normal to the bedding plane and midway between the gas-oil level and the oil-tar oil contact.

The Muskat[2] differential form of the material balance equation has been modified by West[3] using Equation 3, and inserting a factor for aquifer water drive, to give the following general equations:

$$S_{o2} = \frac{(1 + M_{s2})}{(1 + M_{s1})} \frac{\bar{q}_{oc}}{\bar{q}_{or}} \left[\Delta S_o' - S_{o1}\left(1 - \frac{B_{o2}}{B_{o1}}\right)\right] + S_{o1} - \Delta S_o' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where

$$\Delta S_o' = \Delta P \left[\frac{S_{o1}\left(\bar{F}_1 + \bar{F}_4 \frac{\bar{k}_{rg}}{\bar{k}_{ro}}\right) + S_{g1} \cdot \bar{F}_2 + M_{p1} \bar{F}_5 + M_{s1} \bar{F}_6 + \frac{1}{V_{po1}} \frac{dE}{dp}}{1 + \frac{\bar{U}_o}{\bar{U}_g} \frac{\bar{k}_{rg}}{\bar{k}_{ro}}}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

$$M_{s2} = \frac{1 + M_{s1}}{1 - \frac{\bar{q}_{oc}}{\bar{q}_{or}}\left[\frac{\Delta S_o' - S_{o1}\left(1 - \frac{B_{o2}}{B_{o1}}\right)}{S_{o1} - \Delta S_o' - S_{oa}}\right]} - 1 \quad . \quad . \quad (6)$$

$$M_{p2} = \frac{M_{p1}(1 + M_{s2})}{1 + M_{s1}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

$$\bar{q}_{or} = n \cdot q_{ob} \cdot \frac{\bar{K}_o}{K_{ob}} \cdot \frac{U_{ob}}{\bar{U}_o} \cdot \frac{B_{ob}}{\bar{B}_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Then,

$$S_{g2} = 1 - S_w - S_{o2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$\Delta N_p = \frac{V_p}{B_{o2}(1 + M_{s1})}\left[\Delta S_o' - S_{o1}\left(1 - \frac{B_{o2}}{B_{o1}}\right)\right] . \quad (10)$$

$$\Delta T = \frac{\Delta N_p}{365 \times \bar{q}_{or}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and

$$\bar{R} = \bar{R}_s + \frac{\bar{B}_o}{\bar{B}_g} \cdot \frac{\bar{U}_o}{\bar{U}_g} \cdot \frac{\bar{k}_{rg}}{\bar{k}_{ro}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Each of these equations applies to a small pressure interval where the subscripts 1 and 2 represent initial and final values respectively, and a bar superscript, the value at the average pressure.

For the case of the Limon L2m sand, with no primary gas cap or aquifer water drive, the terms M_p, F_5, and $\frac{dE}{dp}$ are zero throughout, and for all pressures:

$$S_g = 1 - S_{wr} - S_o \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Before embarking on the main calculation, the pressure functions F_1, F_2, F_4 and $\frac{U_o}{U_g}$ are derived from PVT data and plotted for the whole pressure range expected. The average values $\bar{F}_1$, $\bar{F}_2$, etc., are taken from the smoothed curves. The volume ratio M_s and segregation area A are determined from the structure-isopach map and plotted as functions of the gas-oil level. In this case, no $\frac{k_{rg}}{k_{ro}}$ measurements had been made, and Corey's[4] method was used for an interstitial water saturation of four percent. This curve and the derived k_{ro} curve are plotted in Fig. 4.

For the calculation of the pressure function F_5, the residual oil saturation S_{oa} in the secondary gas cap is estimated as 0.460 by plotting the fractional flow curve for oil at 2200 psi and selecting the oil saturation for which the average fractional oil flow is 0.001. This is somewhat arbitrary, but makes the best use of available data. A residual gas saturation of 0.500 follows from Equation 13.

The main calculation consists in selecting a succession of small pressure intervals, for each of which ΔN_p, ΔT, $\bar{q}_{or}$, and $\bar{R}$ are calculated.

For the first interval $S_{g1} = 0$, $\frac{\bar{k}_{rg}}{\bar{k}_{ro}} = 0$, $S_{o1} = 1 - S_{wr}$ and $M_{s1} = 0$. The resulting subscript 2 values are then used as subscript 1 values in the next interval.

In succeeding intervals, the average gas saturation $\bar{S}_g$ is

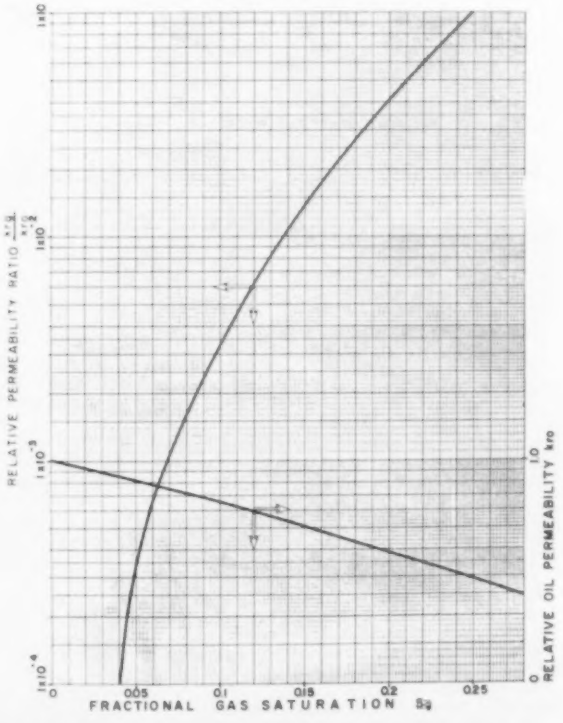


FIG. 4. **Oil permeability** and gas-oil permeability ratios as derived by Corey's method.

estimated by extrapolating previous behavior to give an estimate of $\frac{\bar{k}_{rg}}{\bar{k}_{ro}}$. When S_{g2} is finally calculated, the estimate of $\bar{S}_g$ is checked and the calculation repeated if the difference is significant. Summation of the incremental recoveries and times gives the total recovery and depletion time.

The gas-oil level is read directly from the plot of M_n vs gas-oil level; care must be taken to reduce n in Equation 8 as the level falls below each producing outlet.

These calculations were programmed for punched card business machine, using 10 psi intervals. It is possible, though tedious, to use a desk calculator and 50 psi intervals without much loss in accuracy.

In order to show the maximum likely effect of segregation, sin Θ in Equation 3 was taken as unity. Normally, where it is small, the sine of the dip angle would be used, giving an increased depletion time. The final recovery would remain unchanged.

Results are shown in Fig. 5, 6, and 7. For comparison, results of a simple solution gas drive calculation are also given (broken line) with termination at a gas-oil ratio of 4000 cu ft/bbl. The equations used are derived from the segregation drive equations previously used, but assigning zero values to q_{oc} and M_n.

Overall Recovery and Depletion Time

By extrapolating the available data for pressure and recovery above the bubble point, and estimating the rate of new completion, the recovery and time for the reservoir oil to reach the bubble point may be predicted. These are added to the figures calculated for pressures below the bubble point to obtain the overall recovery and depletion time.

Effect of Segregation Drive

By taking segregation drive into account, the most obvious

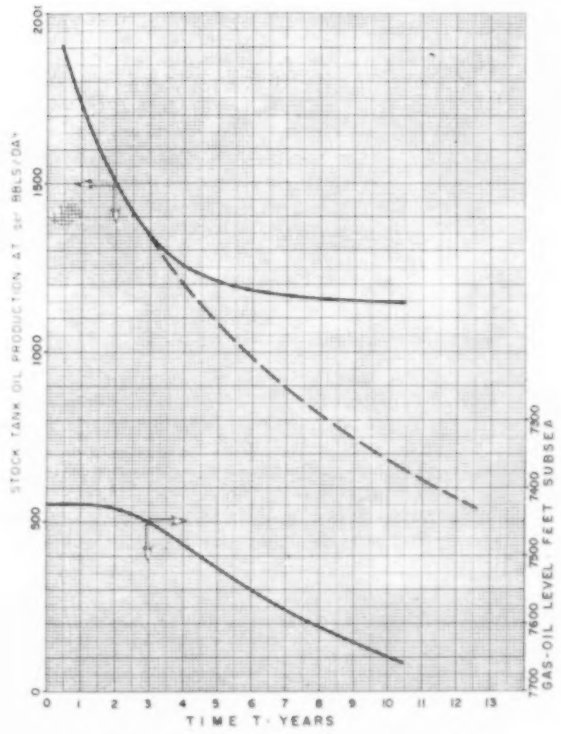


FIG. 6. **Estimated production rate** and gas-oil contact change for the L2m reservoir.

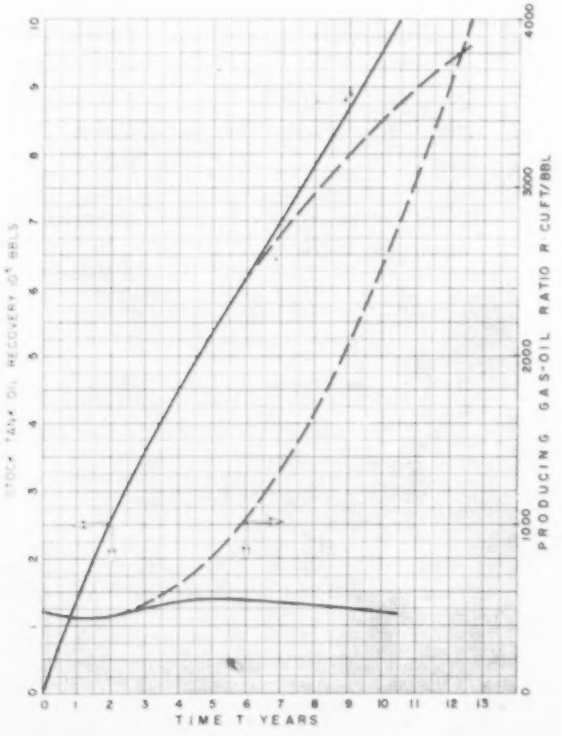


FIG. 5. **Predicted oil recovery** and gas-oil ratios for the L2m reservoir.

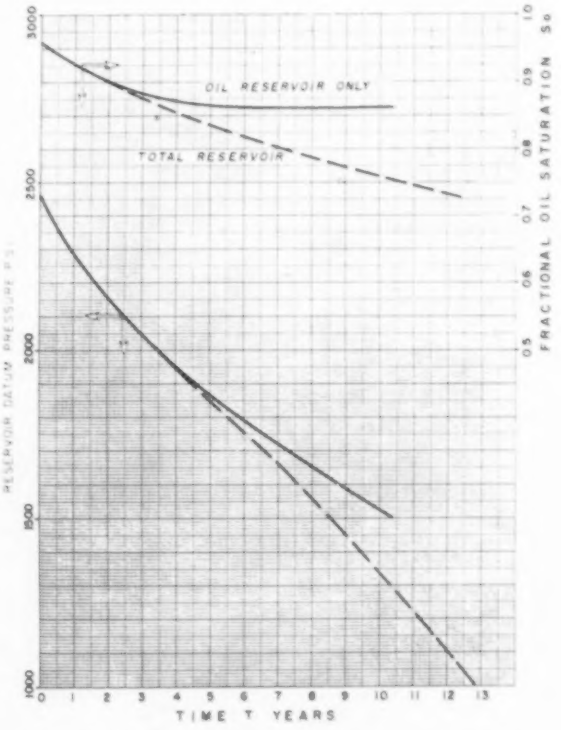


FIG. 7. **Predicted reservoir pressure** and oil saturation of the L2m reservoir.

THE AUTHOR

T. A. O'Brien *graduated from London University in 1944. After six years with the former Anglo-Iranian Oil Company (now British Petroleum Ltd.) and two years with the former Trinidad Leaseholds Ltd. (now Trinidad Oilfields Ltd.), he joined Mene Grande Oil Company in Venezuela in 1954.*

effect appears in the gas-oil ratio behavior. As the segregation rate approaches the offtake rate, a constant high oil saturation is maintained in the shrinking oil reservoir (Fig. 5), which can produce at a correspondingly low ratio (Fig. 4). This high oil saturation also maintains a high oil permeability with consequent improvement in the production rate (Fig. 6) and final depletion time for a given number of outlets.

Comparison of Methods

Use of the segregation-drive equations offers these advantages:

1. If the minimum economic production rate is not known, termination of the recovery calculations is fixed by the position of the gas-oil level relative to the most downdip outlet. This increases the accuracy of predicting ultimate recovery.
2. Predicts when updip wells must be closed-in with high gas-oil ratio and replaced, if necessary, by new downdip outlets. The gas-oil ratio of a producer in the gas cap may be estimated by using a $\frac{k_{rg}}{k_{ro}}$ in Equation 12 corresponding to the residual gas cap saturation.
3. Gives a better estimate of the outlets required for a given depletion time or vice-versa. Payout calculations for gas-lift or injection equipment become more realistic.

Improved Predictions

In high-permeability or steep-dipping reservoirs where a competent aquifer water drive is not present, inprovement in behavior predictions may be expected when segregation drive is allowed for.

NOMENCLATURE

A	Segregating area	sq ft
B_o	Oil formation volume factor	vol/vol
B_g	Gas formation volume factor	bbl/cu ft
C_t	Formation compressibility	vol/vol/psi
C_o	Undersaturated oil compressibility	vol/vol/psi
C_w	Water compressibility	vol/vol/psi
d_o	Saturated oil density	bbl/cu ft
d_g	Free gas density	bbl/cu ft
$\frac{dE}{dp}$	Rate of change of water influx with pressure	bbl/psi
$\overline{F}_1$	Solution of gas pressure function $\frac{B_{g_2}}{B_{o_1}} \cdot \frac{\overline{dR}_s}{dp}$	vol/vol/psi
$\overline{F}_2$	Free gas pressure function $\frac{1}{B_{g_1}} \cdot \frac{\overline{dB}_g}{dp}$	vol/vol/psi
$\overline{F}_3$	Oil shrinkage pressure function $\frac{1}{B_{o_1}} \cdot \frac{\overline{dB}_o}{dp}$	vol/vol/psi
$\overline{F}_4$	Modified shrinkage function $\frac{\overline{U}_o}{\overline{U}_g} \cdot \overline{F}_3$	vol/vol/psi
F_p	Primary gas cap pressure function $(\overline{F}_1 - \overline{F}_3)\, S_{op} + \overline{F}_2\, S_{gp}$	vol/vol/psi
F_s	Secondary gas cap pressure function $(\overline{F}_1 - \overline{F}_3)\, S_{os} + \overline{F}_2\, S_{gs}$	vol/vol/psi
K	Homogeneous fluid permeability	darcys
K_o	Permeability to oil $= K \cdot k_{ro}$	darcys
K_g	Permeability to gas $= K \cdot k_{rg}$	darcys
k_{ro}	Relative permeability to oil	dimensionless
k_{rg}	Relative permeability to gas	dimensionless
M_p	Ratio: $\frac{\text{pore vol of primary gas cap}}{\text{pore vol of oil reservoir}}$	dimensionless
M_s	Ratio: $\frac{\text{pore vol of secondary gas cap}}{\text{pore vol of oil reservoir}}$	dimensionless
N	Stock-tank oil in place at initial reservoir pressure	bbl
n	Number of producing outlets	dimensionless
N_p	Cumulative stock tank oil production	bbl
P	Reservoir pressure	psi
q_{oc}	Segregation rate in stock-tanks units	bbl/day
q_{or}	Total production rate in stock-tank units	bbl/day
q_o	Per-well production rate	bbl/day
R	Producing gas-oil ratio	cu ft/bbl
R_s	Solution gas-oil ratio	cu ft/bbl
S_o	Oil saturation	dimensionless
S_g	Gas saturation	dimensionless
S_w	Total water saturation	dimensionless
S_{wr}	Interstitial water saturation	dimensionless
T	Time	years
U_o	Saturated oil viscosity at reservoir conditions	centipoises
U_g	Gas viscosity at reservoir conditions	centipoises
V_p	Total pore volume of reservoir	bbl

Other Subscripts

- 1 ..... at beginning of small pressure intervals ΔP
- 2 ..... at end of small pressure interval ΔP
- b ..... at bubble-point pressure
- i ..... at initial reservoir pressure
- p ..... in primary gas cap
- s ..... in secondary gas cap

A bar superscript represents the average value in a small pressure interval ΔP.

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Socony Mobil of Venezuela Minimizes Pipe Failures By . . .

Hydrostatic Pressure Testing Tubular Goods In the Field

Quality of foreign-made casing and tubing was materially improved by a thorough and consistent field testing program. In two years, more than 80,000 joints of pipe tested

Carlos Bendiks
Socony Mobil Oil Company de Venezuela

THE QUALITY of casing and tubing supplied by foreign manufacturers and made to comply with API Standard 5A was materially improved through a program of hydrostatic pressure testing carried out in the field. The testing program was initiated in November 1955, and this report includes the results through July 1957.

Socony Mobil Oil Company de Venezuela starting buying foreign-made casing and tubing in the latter part of 1951. Initial quantities were small, but were gradually increased up through late 1955. The usual procedure was to order the tubular goods to comply with API Standard 5A. The mills would then manufacture such goods and an independent organization would test the pipe according to API specifications. Those goods which passed inspection were then shipped to Venezuela. From warehouse stocks, the tubular goods would be used when needed.

Many foreign mills have been approved by the American Petroleum Institute to use its monogram, since quality of their products met API standards for oil country tubular goods. A large number of mills were inspected and certain of these were chosen as a source of supply. These mills employed the usual methods of inspection as used by U. S. mills, to comply with API Standard 5A. During this period (late 1951 through November 1955) of foreign purchasing, no serious defects were noted or experienced, except for relatively minor ones. Results were mainly satisfactory. It had been reported, however, that other operators in Venezuela had experienced some serious failures.

FIG. 1. **Hydrostatic pressure testing hookup** at the warehouse storage yards of Socony Mobil of Venezuela. Pump is in foreground.

FIG. 2. **Swadge on pin end** connection of casing on hydrostatic pressure test.

TABLE 1. Summary of Casing Testing Program.

Mill	Number of Joints Tested	Number of Joints Rejected	Reason for Reject: Burst	Mill Coupling Leak	Pin End Leak	Box End Leak	Crookedness
A	6,360	540	31	204	130	148	27
B	5,819	231	0	157	44	29	1
C	7,630	209	2	56	66	87	2
D	476	5	0	3	0	2	0
E	8,180	269	3	64	91	105	6
F	3,687	363	3	277	18	65	0
TOTALS	32,152	1,617	39	761	349	436	36
Percent	—	5.03%	0.12%	2.36%	1.08%	1.36%	0.11%
U.S. TOTAL	1,433	16	0	2	10	4	0
Percent	—	1.12%	0.%	0.14%	0.70%	0.28%	0%

TABLE 2. Qualitative Summary of Casting Testing Program.
(All values are percent of total joints tested from Table 1.)

Mill	Purchase Order*	Total % Rejected	Reason for Reject: Burst	Mill Coupling Leak	Pin End Leak	Box End Leak	Crookedness
A	a	5.02	1.93	3.09	0.00	0.00	0.00
	b	9.01	0.95	0.63	3.00	3.72	0.71
	c	8.54	0.29	3.89	1.86	2.09	0.37
Overall Percentage		8.49	0.49	3.21	2.04	2.33	0.42
B	a	4.83	0.00	3.35	0.90	0.56	0.02
	b	0.52	0.00	0.09	0.17	0.26	0.00
Overall Percentage		3.97	0.00	2.70	0.76	0.50	0.02
C** Overall Percentage		2.74	0.03	0.68	0.86	1.14	0.03
D** Overall Percentage		1.05	0.00	0.63	0.00	0.42	0.00
E	a	3.29	0.09	1.32	0.41	1.42	0.05
	b	5.34	0.00	1.05	2.18	2.11	0.00
	c	2.47	0.07	0.15	1.09	0.80	0.36
	d	2.90	0.00	0.31	1.52	1.07	0.00
	e	2.59	0.00	0.67	0.81	1.11	0.00
	f	0.48	0.00	0.06	0.42	0.00	0.00
Overall Percentage		3.29	0.04	0.78	1.11	1.28	0.07
F	a	17.54	0.16	14.61	0.39	2.37	0.00
	b	2.84	0.00	0.74	0.81	1.29	0.00
	c	10.53	0.11	8.62	0.11	1.76	0.00
Overall Percentage		9.84	0.08	7.51	0.49	1.76	0.00
U. S.** Overall Percentage		1.12	0.00	0.14	0.70	0.28	0.00

*Chronological order in which shipments were received and tested after arrival.
**Only one shipment tested.

TABLE 3. Comparison of Rejections by Manufacturers.
(Based on overall percentages from Table 2.)

Total Rejects: Mill	%	Pin End Leaks: Mill	%
"F"	9.84	"A"	2.04
"A"	8.49	"E"	1.11
"B"	3.97	"C"	0.86
"E"	3.29	"B"	0.76
"C"	2.74	U. S.	0.70
U. S.	1.12	"F"	0.49
"D"	1.05	"D"	0.00

Burst: Mill	%	Box End Leaks: Mill	%
"A"	0.49	"A"	2.33
"F"	0.08	"F"	1.76
"E"	0.04	"E"	1.28
"C"	0.03	"C"	1.14
"B"	0.00	"B"	0.50
"D"	0.00	"D"	0.42
U. S.	0.00	U. S.	0.28

Mill Coupling Leaks: Mill	%	Crookedness: Mill	%
"F"	7.51	"A"	0.42
"A"	3.21	"E"	0.07
"B"	2.70	"C"	0.03
"E"	0.78	"B"	0.02
"C"	0.68	"F"	0.00
"D"	0.63	"D"	0.00
U. S.	0.14	U. S.	0.00

VENEZUELA

Satisfactory usage of foreign-made tubular goods during the aforementioned period was abruptly changed by the collapse failure of 5½-in. casing in a 12,192-ft wildcat well. This single failure precipitated abandonment of a $750,000 wildcat well which had a potential of 700 bbl of oil per day.

Casing Testing Procedure

After this casing failure, hydrostatic field testing of all foreign-made casing (5½-in. and 6-in.) and tubing was commenced in November 1955. More than 98 percent of this was N-80 grade.

Tubular goods, after arrival at a Venezuelan port, are transported to Socony Mobil yards. Here, all oil-string casing undergoes a hydrostatic test. The customary procedure for testing each joint is as follows:

a. Note manufacturer, requisition number, description, and check visual appearance (for rust and crookedness).

b. Remove thread protectors and visually inspect all threads.

c. Apply thread lubricant and make up pressure test plugs.

d. Fill joint with water, allowing trapped air to escape through a bleed-off valve, and pressure test to 80 percent of the minimum yield value, namely:

5½-in., 17 lb, N-80 casing	7100 psi
5½-in., 20 lb, N-80 casing	8400 psi
6-in., 18 lb, N-80 casing	6100 psi
6-in., 23 lb, N-80 casing	8100 psi
6-in., 18 lb, J-55 casing	4200 psi

As specified by API Standard 5A (February 1956). This pressure is held for a minimum of 5 seconds. This is a similar procedure to that followed at the mills. If a joint is rejected, it is marked with yellow paint and sent to the salvage shop for repairs.

Tubing Testing Procedure

All tubing is pressure tested in the well. The tubing is visually inspected as it is picked up, then measured, and run in the well. After running all the tubing and cleaning out to bottom, a plug is inserted and pumped down to pressure test the tubing. If a joint fails, the string is pulled, the failed joint is replaced and the procedure repeated.

Results of Tests

Tables 1, 2, and 3 summarize results of the testing program thus far. Table 1 is self-explanatory. In Table 2, the object is to show the relative improvement of each subsequent shipment.

TABLE 4. Tubing Failures.

Description	Mill	Pressure at Failure psi
2½"—6.5 lb/ft, N-80	"A"	2,000*
idem	"	2,000*
idem	"	2,000*
idem	"	3,500*
idem	"	5,400*
idem	"	2,800*
idem	"	4,700*
idem	"	2,500*
idem	"	3,500
idem	"	4,300
idem	"	4,500
idem	"	3,300*
idem	"	2,000*
idem	"	3,800
idem	"	4,600
idem	"	4,000
idem	"	2,500
idem	"	5,000
2"—4.7 lb/ft, N-80	"	Tensile failure at 46,800 lb*
idem	"	2,500
idem	"B"	3,200
idem	"	3,000
idem	"C"	4,500
idem	"E"	Washout of inclusion*
idem	"	?
idem	"	Collapsed, pressure unknown

*Failed before June 1956 (12 failures).

Note, for example, that mill "A" casing burst failures in the first purchase is 1.93 percent. Subsequent purchases of casing indicate improved quality material as evidenced by the decrease in burst failures. Table 3 compares the various manufacturers according to type of rejections. Table 4 summarizes the tubing failures.

Overall Findings

By far the most serious of rejections is that due to burst failure. Out of a total of 39 failures to date, 31 of these were attributed to casing manufactured by mill "A." Referring to Table 2, however, it is noteworthy to see that the frequency of failures due to burst of mill "A" casing has decreased considerably. The quality of steel supplied to this mill has been improved and this is responsible for the decrease in the number of burst failures.

In almost all cases of burst, material had burst due to non-metallic inclusions that occurred during manufacture of the steel. Burst failures were always in a longitudinal direction (see Fig. 4, 5, 6, and 7). The majority of this pipe has been manufactured by the Pilgrim Process in which any non-metallic inclusions present are elongated longitudinally.

Comparison with U. S. A total of 1433 joints of U. S. manufactured casing was tested solely as a standard of comparison. Whereas U. S. rejections are in the order of one percent, foreign manufacturers' rejections are almost five times as high. It should be noted, from Table 1 that nearly half (2.36 percent) of these rejections are due to mill coupling leaks. This is an indication that a poor grade, short-lived thread compound was used. In some cases, the thread lubricant bulged out and was in a dry form.

Another reason for high percentage mill coupling leaks may be due to the effect of "out of round" of the collar. This can best be remedied by rigidly designed thread protectors.

The highest rejections due to mill coupling leaks are those of mill "F" (see Tables 1 and 2). Other foreign manufacturers are much lower percentagewise. Therefore, the indication is that this mill uses a very inferior type of thread compound and/or inferior collars, as noted by a relatively high percentage of box end leaks and low pin end leaks.

Casing threads. Pin and box end leaks are distributed quite evenly among the foreign manufacturers, with mill "A" having these failures slightly higher than the others. Cause of this is undoubtedly due to poor threads. Apparently, foreign casing in general, and mill "A" pipe in particular is not threaded to as close a tolerance as U. S.-made casing. As stated in the mill inspection reports, however, all threads were checked and came within API specifications. If such is the case, it might be concluded that API standards on casing threads are not sufficiently rigid.

Crookedness, in general, is usually due to poor or improper handling techniques and this deficiency is not necessarily the fault of the manufacturers. In all cases, it is a minor percentage of the total rejections.

Tubing failures. Tubing failures in two wells in August 1955, caused considerable concern and thus it was decided to pressure-test all tubing before the well is perforated. Since then, 51,094 joints have been pressure-tested. Out of a total of 26 tubing failures to date, 20 were manufactured by mill "A." The same comments as made on their casing burst failures are applicable to their defective tubing.

Cost of tests. The contractor's charge for pressure testing casing is $3.60 per joint. Other direct costs have brought the unit cost to $6 per joint. More than 32,000 joints have been tested, amounting to a total cost of approximately $193,000.

The service company charge for pressure testing tubing in the well is $480. Unit cost for testing tubing has been $1.28 per joint. Stated differently, the cost of finding a bad joint is $2450. This cost is not prohibitive if it eliminates a possible fishing job from tubing failures.

Testing Program Beneficial

The field testing program has been effective in increasing the quality of tubular goods delivered, as evidenced by decreasing percent rejections for all manufacturers. Mill "A" burst failures have dropped from 1.93 to 0.29 percent. (See Table 2).

Out of 32,152 joints of casing which have been pressure-tested, 1617 joints

THE AUTHOR

Carlos Bendiks *is a petroleum engineer for Socony Mobil Oil Company in Eastern Venezuela. A native of Venezuela, he was educated in the U. S., receiving his engineering degree in 1953 from Polytechnic Institute of Brooklyn, New York. After graduation, he was called to active duty as a commissioned officer in the U. S. Army Corp of Engineers, serving two years, most of which was in France. In 1955, he joined Socony Mobil.*

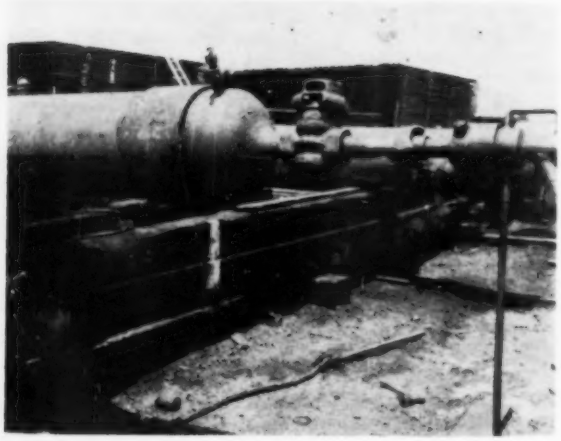

FIG. 3. **Box end connection** for casing pressure test showing pressure feed line.

FIG. 4. **Latest and worst burst failure** resulted from double layer of laminated steel.

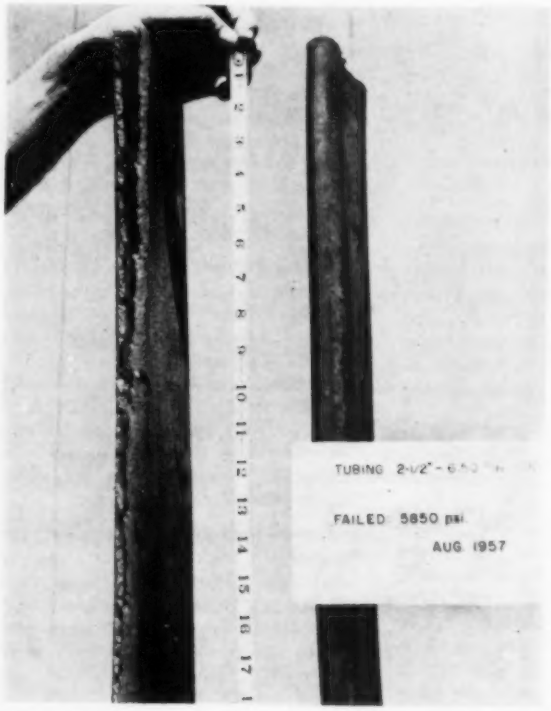

FIG. 6. **Joint collapsed** while going in hole at 12,000 ft for production test.

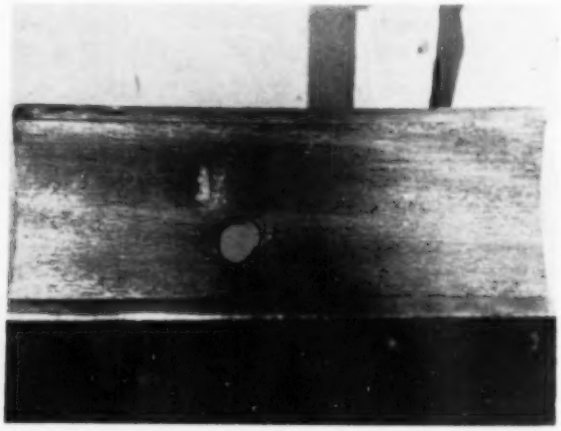

FIG. 5. **Washout** of non-metallic inclusion in tubing is indicated in this sample.

FIG. 7. **Typical washout** of non-metallic inclusions in tubing. Joint failed while completing wildcat well subsequently abandoned due to casing collapse.

(or 5.03 percent) have been rejected.

In all (39) cases of burst failure, the casing burst due to the presence of non-metallic inclusions. These inclusions occurred during manufacture of the steel.

In general, highest percentage of rejections are due to mill coupling leaks (2.36 percent) followed in order by: Box end leaks (1.36 percent); pin end leaks (1.08 percent); burst (0.12 percent), and crookedness (0.11 percent). (See Table 1.)

The casing testing program has cost over $193,000, or $6 per joint tested.

Foreign mills generally and Mill "F" in particular, have used an inferior type of thread compound.

Out of 51,094 joints of foreign-made tubing tested, 26 (or 0.043 percent) have failed.

The unit cost to test tubing is $1.28 per joint, including rig time.

Acknowledgment

The author wishes to express his appreciation for permission granted by Socony Mobil Oil Company de Venezuela to publish this paper. Much of the material is covered in company files and reports, under the authorship of several individuals.

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FIG. 1. **The Boscan field,** about 25 miles southwest of the town of Maracaibo, on the western side of the Lake, consists of 296 producing wells.

Heaviest Crude In Venezuela

Richmond Solves Viscous Oil Problem At Boscán

Average 10 deg API gravity crude posed many production and pipelining difficulties in this Maracaibo Basin field. Their solution developed a large source of road-building materials

Guy Lebourgeois
Maracaibo, Venezuela

THE DISCOVERY in March 1946 of the Boscán low-gravity, high-viscosity crude oil accumulation presented the Richmond Exploration Company with a multitude of problems almost unique in the industry. Solution to these problems through experience and trial methods has resulted in the successful development of a large source of road-building materials.

Among the oil companies operating in Venezuela, to which heavy crude means some 14 to 15 deg API gravity oil, the name Boscán has practically become a synonym of "viscous fluid." Indeed, Boscán crude has an average 10 deg gravity fluctuating from 9 deg to 12 deg, and an average viscosity of 26,000 seconds, Saybolt Universal at 122 F fluctuating from 17,000 to 50,000 SSU. This asphalt-looking oil has to be pumped out of the ground, shipped 25 miles away and loaded on tankers.

When the Boscán field was discovered, the technical obstacles brought up by the physical characteristics of its crude made questionable the commercial exploitation of a petroleum so difficult to produce. However, three years later, Richmond was shipping 14,000 bbl per day of Boscán crude. Even if the figure does not seem impressive, it means the practical answers to a large sequence of major production problems had to be solved within the rates of the available equipment through constantly improving methods and designs. The drilling of a Boscán well is not a difficult task; obstacles start arising after the rig has been moved.

Based on an original paper presented by the author at the First Venezuelan AIME Regional Meeting held in Caracas, November 1956, and published in *The Journal of Petroleum Technology* in May 1957, under the title, "Producing Viscous Fluids."

Geology

The Boscán field is located 26 miles southwest of Maracaibo in the State of Zulia in the western part of the Maracaibo Basin. The stratigraphic sequence encountered in and above the production section in the Boscán area includes Eocene, Oligocene, Miocene and Pliocene sediments.

The Upper Eocene consists of the Las Flores formation with inter-bedded sands and dark gray carbonaceous shales. In the upper part, two zones of beach and bar sands (designated as Upper Boscán and Lower Boscán) produce heavy oil.

The lower Oligocene overlies the Eocene and contains poor to well de-

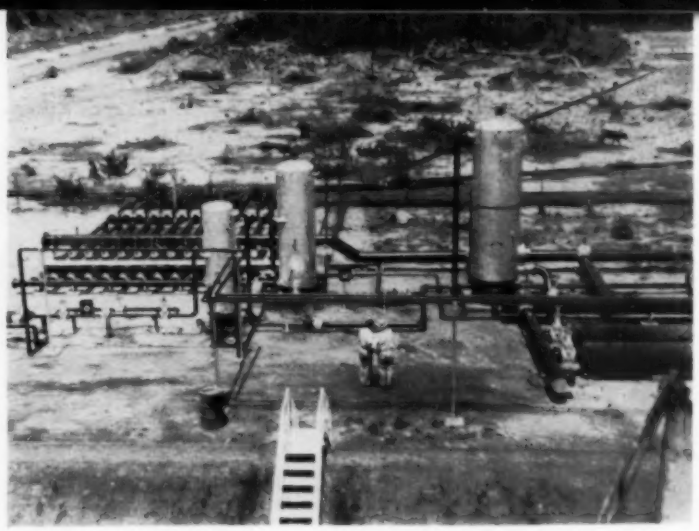


FIG. 2. **Typical gathering station** in the Boscán field. Six and 8-in. flow lines bring crude into the 19 gathering stations for separation and heating in the insulated parallel heaters at right foreground.

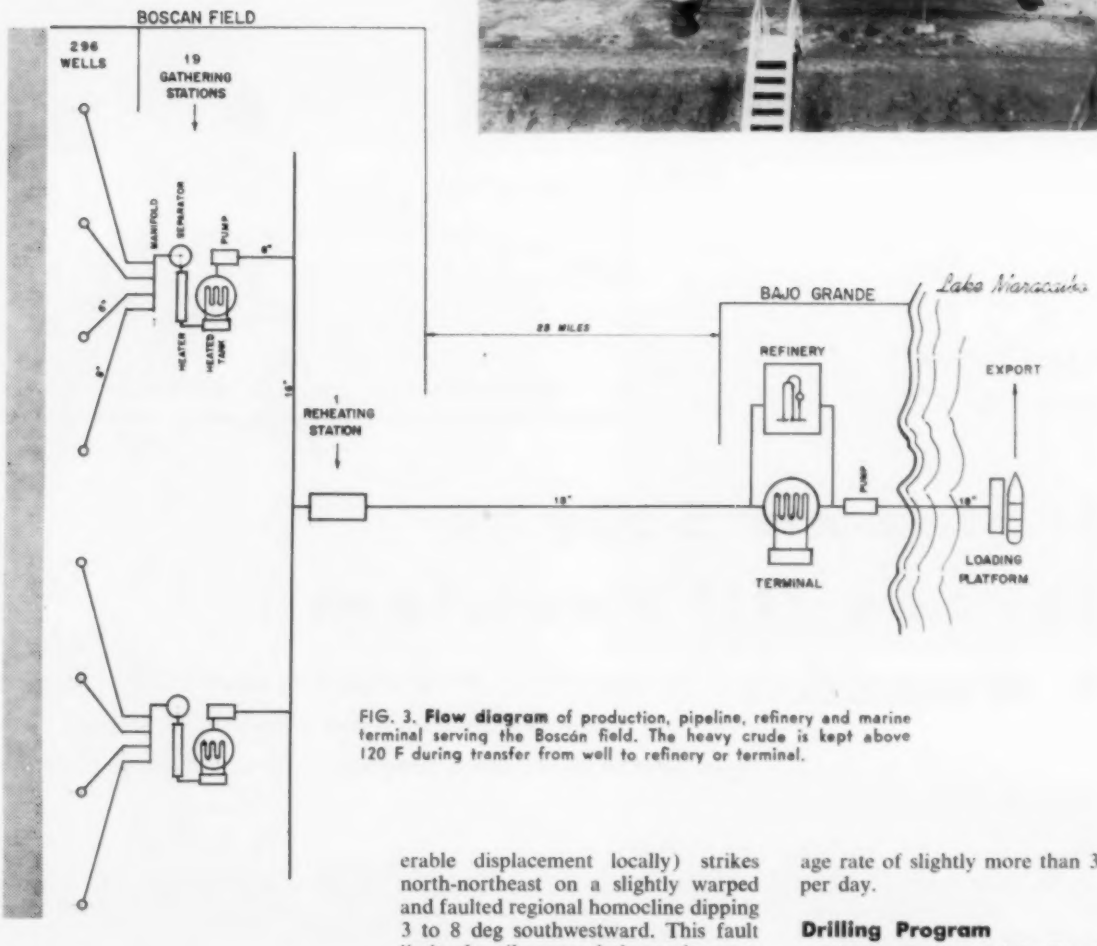


FIG. 3. **Flow diagram** of production, pipeline, refinery and marine terminal serving the Boscán field. The heavy crude is kept above 120 F during transfer from well to refinery or terminal.

veloped beach sands interbedded with light gray sandy claystone. Effectively permeable sands in this formation (designated Basal Icotea locally) are oil productive. The middle of Oligocene, principally claystone, contains thin sands which are oil productive in the eastern part of the field. This is Middle Icotea.

Basal Icotea, Upper Boscán and Lower Boscán sands constitute the principal reservoirs of the Boscán field. Effective porosity of these sands averages about 26 percent.

The accumulation is controlled by variations of lithology and faulting. The main Boscán fault (with considerable displacement locally) strikes north-northeast on a slightly warped and faulted regional homocline dipping 3 to 8 deg southwestward. This fault limits the oil accumulation to its western side. Several relatively minor faults occur locally within the productive area.

The oil productive sands generally dip southwestward from about 5400 ft in the northeastern part of the field (where their net effective thickness is slightly less than 250 ft) to about 8600 ft at the southwestern edge of the field (where their net effective thickness is less than 50 ft).

The cumulative production as of October 31, 1956, was 70,200,000 bbl, and the field, which averaged 44,900 bbl per day during 1955 and 51,200 bbl per day during the first semester of 1956, is actually producing 80,000 bbl per day from 296 wells having an average rate of slightly more than 300 bbl per day.

Drilling Program

The development of the Boscán field was initiated on 24-acre spacing, but later was modified to 214-acre spacing. This locates wells at one kilometer intervals. A Boscán development well is drilled in 17 to 27 days using a diesel-powered rotary rig. Drilling equipment is torn down, skidded to the next location and rigged up in two to six additional days.

Well casing consists of 13⅜-in. surface casing set at approximately 500 ft and an 8⅝-in. production string.

Considerable care has been given to pipe stress and, for the purpose of avoiding possible failures, the casing is thoroughly subjected to a double static test. A 6⅝-in. slotted and blank liner is hung in the casing through the

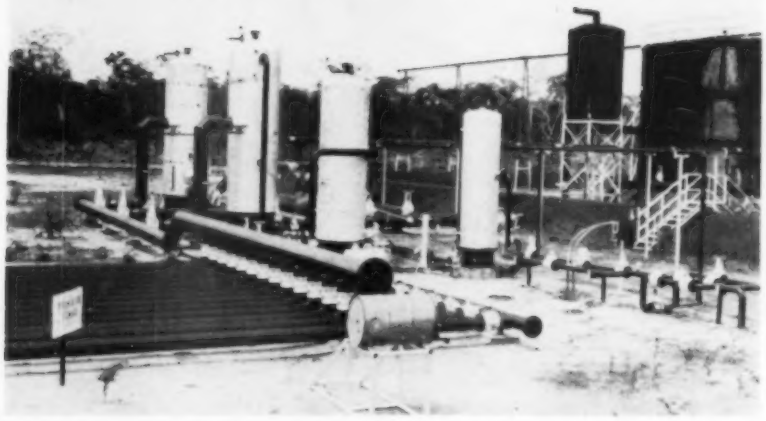


FIG. 4. **Flowline manifold** at one of the 19 gathering stations in the Boscán field. Note the large pipe sizes. Heater tank is at extreme right.

producing sands. Cementing the liner is not a usual procedure in Boscán drilling techniques. The slot pattern is based on 2.5 times the 10 percentile point.

Wells are drilled with a gel base mud conditioned with organic thinners and water loss control additives. Some experimenting with oil base muds was performed but was not found practical.

At the beginning of the field development, a central mud system was installed. It included a mixing station and a network of mudlines distributing the drilling fluid to the rigs. Plugging of the lines and excessive operating cost caused the system to be abandoned.

Producing Practices

The first element in the producing sequence is a 4-in. pump having a 3¾-in. bore which lifts the crude to the surface through a string of 4-in. tubing. This pump is actuated through ⅞-in. to 1⅛-in. sucker rods by an air counterbalanced pumping unit driven by a gas engine. The excessive fatigue caused to walking beams and gear boxes by the unusually high loads and torques encountered have required the use of one of the largest types of pumping equipment manufactured. Although the first pumping units installed in the field were rated at 30,000 lb maximum load and 456,000 in.-lb peak torque, units designed for 35,000 lb load and 912,000 in.-lb torque are now standard equipment in Boscán.

The field now has about 300 wells and had produced 100 million barrels by September 7.

Pump installations. One of the first wells drilled used 5-in. casing in lieu of tubing and had a 5-in. pump actuated on 144-in. stroke by a pumping unit rated at 40,000 lb load and 750,000 in.-lb torque.

Depth of the pump is determined by a number of factors which include: Weight of the fluid column, back pressure caused by the displacement of the oil through the flowlines, operating pressure of the gas-oil separators, maximum capacity of the pumping units, stress of the sucker rods, friction effects, pumping speed and length of the stroke. Most of these factors are directly affected by the viscosity of the fluid.

Optimum pumping depth for a typical Boscán well was determined by intensive dynamometer work. The maximum speed of pumping is limited by the rate of drop of the moving assembly through the viscous fluid. Within the limits of normal equipment maintenance, an average well pumping at a speed of 12 spm on a 120-in. stroke usually has a 3¾-in. bore pump set at 3300 ft. However, some wells producing particularly viscous crude are

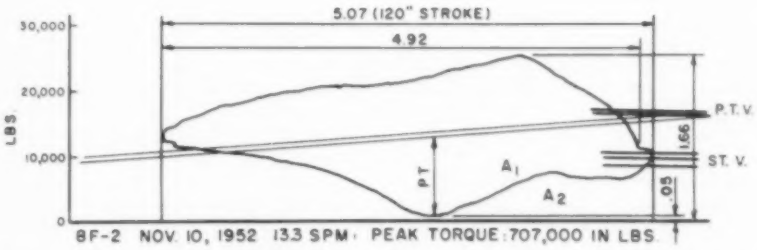


FIG. 5. **Typical dynamometer card** taken on one of the Boscán field wells. Note the extreme peak torque indicated . . . 707,000 in.-lb . . . in pumping the heavy crude.

FIG. 6. **Large pumping unit** required to pump heavy Boscán crude. This unit has a 120-in. stroke, 35,000-lb load and 912,000 in.-lb torque.

limited to a maximum 100-in. stroke and the average field speed is about 10 spm.

An interesting experience is to watch the starting-up of the pumping unit on a Boscán well which has been shut in for a few days. When a well is shut in, a simple phenomenon of heat exchange causes the temperature of the motionless column of fluid in the hole to rapidly decrease to that of the surrounding formations with a resulting increase in the viscosity of the oil. When the pumping unit is started, the plunger and rods drop so slowly through the heavier fluid that the upstroke part of the pumping cycle is initiated by the unit before the plunger reaches the bottom of its effective downtrip. The rising carrier bar meeting the falling polished rod clamp results in a shock which is reflected on dynamometer charts as a prohibitive peak load exerting an excessive stress on the most carefully designed sucker rod string.

The counterbalance effect of the pumping units is properly adjusted through periodical dynamometer analyses. Along with sound logging practices, these are also used for the control of the subsurface equipment.

Flow lines. Crude from the well has to reach the nearest gathering station, which in some cases is more than a mile distant. The necessity of an efficient flow and the imperative limitation of the back pressure at the well head have determined the use of abnormally large flowlines; 6, 8 and even 10-in. in diameter.

The temperature of the fluid in the flowline influences its behavior, for it affects the apparent viscosity, thus the friction effect, and fluctuations in tubing head pressure are directly related to atmospheric temperatures. Experimental installation of heaters of particularly long flowlines has been investigated but not found practical.

Gathering stations. The Boscán field is served by 17 gathering stations. The crude is received at the stations by gas-oil separators operated at an average pressure of 30 psi, which is sufficient to force the oil into the 5000-bbl tanks, but does not constitute excessive back pressure on the well pump. The gas is distributed through a field system and used as fuel in all engines and boilers operating in Boscán.

FIG. 7. **Boilers and pumps** at a gathering station. Boilers supply steam to heat crude in tanks at left prior to pumping the crude to the refinery and marine terminal 25 miles to the east.

The heating program which facilitates the 26 to 35-mile journey of the crude to the loading dock begins at the gathering station. Pumped out of the hole at an average of 120 F, the fluid reaches the station at a lower temperature, frequently below 80 F. A viscosity chart is not necessary to visualize the form taken by the fluid at such temperatures.

The temperature of the oil at the gathering station is increased to an average of 220 F by heaters and coils installed in the storage tanks. Gas burning boilers supply the steam which feeds all the heating system.

Shipping line. From the stock tanks, Boscán crude is pumped through 8 to 10-in. shipping lines to a reheating station located at the departure of the pipeline. Here, heaters receive the oil at 160 F and re-establish its temperature at 220 F. This operation maintains the apparent viscosity of the crude sufficiently low to facilitate its displacement through the 25-mile long 18-in. pipeline to the marine terminal. For the purpose of limiting heat exchanges, all shipping lines are insulated with fiber glass and buried in the ground.

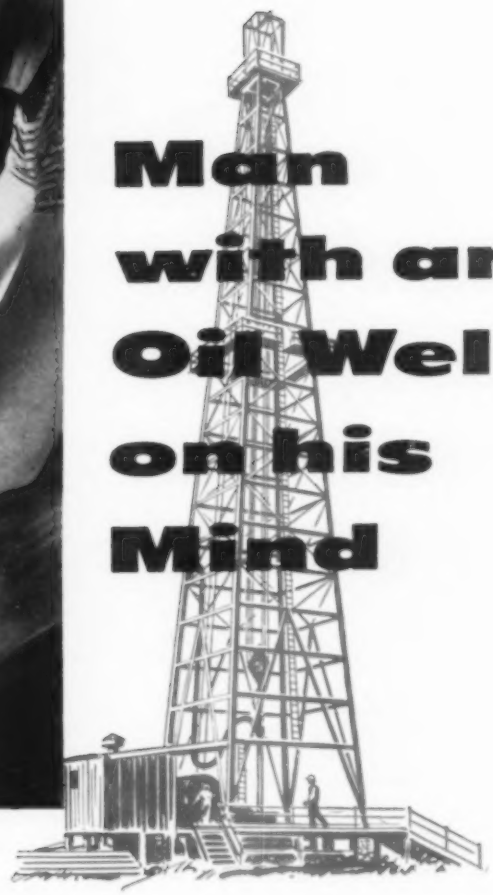
Heater stations. Initially, the oil was heated to only 180 F and the temperature loss caused such an increase in viscosity that the crude could barely be displaced through the pipeline. Consequently, a reheating station was installed midway between the field and the terminals. The crude entered the station at 120 F and 50 psi averages and heaters re-established its temperature to the usual 180 F. Pumps returned the oil to the line at 400 psi. Since installation of the reheating station at the origin of the pipeline, the need for intermediate heaters along the line has been eliminated.

Marine terminal. The marine terminal is located at Bajo Grande, three miles south of Maracaibo. Its present storage capacity of 1,230,000 bbl results from a tank farm including six 80,000 and three 250,000-bbl tanks. Another 250,000-bbl tank is being constructed. The tanks receive and maintain the crude at a storage temperature of 160 to 180 F. Heating is provided by coils utilizing the exhaust steam from the nearby company refinery. Formerly, boilers burning Boscán crude were used to supply the necessary steam. Two 18-in. submarine lines take the crude 1½ miles offshore to a loading platform where it is pumped aboard the tankers at an average temperature of 160 F.

The Author

Guy Lebourgeois *is now associated with A-Z Export S. A. at Maracaibo, Venezuela, although he was until earlier this year chief production engineer for Richmond Exploration Company. He was graduated from the Universities of Paris and Caen in science and mechanical engineering. Following his work in Paris as an aeronautical engineer, he joined the French Engineers Corp during World War II and was trained in electronics. He joined Richmond Exploration Company in 1948 as a mechanical engineer and was named production engineer the following year. He became Richmond's chief production engineer in January 1957 shortly before his association with A-Z Export, S. A., to handle instrumentation and special production problems.*

Man with an Oil Well on his Mind



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Tanker heating coils. During the ocean journey the temperature of the oil is kept at 140 F by the ship heating system. Richmond recommends that the temperature be raised to 160 F when the tanker nears port in order to facilitate unloading operations. If a proper temperature is not maintained, discharging problems arise. To illustrate, a certain shipment of 100,000 bbl of Boscán crude was loaded at Bajo Grande terminal in 24 hours. The ship was not heated during the trip to Europe. Consequently, 10 days after starting to unload, half the cargo was still aboard.

The present loading capacity of 8000-bbl per hr is being increased to 15,000 bbl per hr. During the past years, when the bar allowed ocean tankers to leave Lake Maracaibo only slightly loaded, they formerly completed their cargo from a converted tanker anchored in the open sea at the port of Las Piedras. This floating storage was supplied from the marine terminal by small 25,000-bbl lake tankers able to easily cross the bar. Naturally, this floating storage was constantly heated in order to facilitate the transfer of the crude. Since the dredging of the Lake Maracaibo channel, this procedure has been discontinued. From well to ship, this is the producing sequence of the Boscán crude.

Special Problems

Apart from the basic difficulties in routine production, the viscosity of the fluid has caused many special problems which had to be solved in order to sustain continuous production.

Subsurface surveys. One of the most difficult and expensive tasks in the Boscán field has been collecting reservoir data because instruments could not be run through the crude in the normal manner. For instance, a depth-pressure recorder heavily weighted with sinker bars practically floated on Boscán crude and did not reach a necessary depth within the time range of the driving clock. Consequently, it was necessary to move a workover rig to the location, pull out the tubing and then run the instrument (together with a heavy weight) on the sand line. Sometimes, lighter assemblies could be run through the tubing and the pump standing valve, but if the well had to be killed or if buildup pressure tests were intended, the recorder had to be hung at the bottom of a tail of sucker rods connected to the pump shoe. The initial cost was extremely high and the excessive downtime caused a considerable loss of production.

Presently, all types of instruments including bottom-hole samplers and depth-pressure recorders are run on measuring lines through the annulus between casing and tubing. This improvement, which enables Richmond to perform subsurface surveys for a small fraction of their former cost and about 10 percent of the time previously needed, is due to the design of special flexible assemblies and tubing hangers. The size of the tubing and the lack of space in the well head connections have prohibited the use of a valve at the annulus entry and originated tolerances between the run assembly and the surrounding equipment eventually smaller than ⅛ in. Consequently, the annulus is entered through a retrievable pressure plug fitting on which the lubricator is set. The 1¼-in. OD assembly has an average length of 27 ft. Hydraulically powered wireline units are necessary to perform the run. Cooling of the driving fluid overheated by the abnormal friction caused by the pulling load has been one of the main problems now satisfactorily solved. To date, dozens of runs have been successfully performed in Boscán wells using the techniques and equipment recently developed by Richmond.

FIG. 8. **Pipeline reheating station** where oil is received through 16-in. lines at about 160 F and heated to 220 F before sending the crude to the refinery through an 18-in. line.

Fishing. Fishing is also a problem in heavy crudes. The viscosity of the fluid suppresses the efficiency of feeling runs, and the operation of impression blocks and retrieving tools is defective. However, the difficulty is easily remedied by displacing the crude with water, diesel-oil or mud.

Separation. Separation of oil and water is difficult. The water, having the same 10 deg API gravity as the Boscán crude, stays suspended in the oil. Chemical additives are needed to control the formation of emulsions caused by the heating process.

Fortunately, the Boscán crude produced has a water cut which does not create a problem. However, activated by the heating process, the fluid has a definite tendency to foam. This could eventually result in a serious storage-capacity problem. The injection of anti-foam agents in the gathering-station manifolds has provided a successful solution.

The peculiar problems posed by the commercial production of Boscán crude are many and have been puzzling at the time of their appearance. However, satisfactory approaches have always been found which finally led to a practical answer.

The possibility of reducing the viscosity of the fluid at the initial point of the producing line, that is in the hole, has of course thoroughly been studied, for any economical solution would be of outstanding interest. Some experiments, including the injection of lighter petroleum down the hole, gas lift and naphta recovery, are actually in progress, but no positive procedure has yet been developed.

Refining

In order to meet the increased demand for Boscán paving asphalt, Richmond decided to build at the Bajo Grande terminal, a refinery which processes 10,000 bbl of crude a day producing 78 percent asphalt and 40,000 bbl per day of topped crude. The distillation process yields naphtha, kerosine and fuel oils as by-products.

To facilitate handling without sacrificing the outstanding quality of the product, Boscán asphalt is shipped as a cut-back product. Using a fuel oil, the asphalt is cut back until it reaches the average viscosity of Boscán crude and is heated to the Boscán shipping temperature of 160 F. Loading and unloading operations can then be carried out under conditions similar to those necessary for handling of the crude.

Problems Remain

These few comments indicate how Boscán crude is produced. While many of the seemingly insurmountable problems have been overcome, many opportunities remain for ingenuity and improvement of present techniques. Time and experience will surely produce advancements. ★ ★ ★

Eastern Venezuela

Area of Promise

Pilot Water Flood Successful in Tucupido Field

Atlantic Refining operates a secondary recovery project that points way to more oil production in many Venezuelan fields

S. L. Chu and E. L. Baldwin

Primary Production History

Tucupido field is situated approximately nine miles northwest of the town of Tucupido in the state of Guarico, Eastern Venezuela. Approximate location is shown in Fig. 1.

It was discovered by Venezuelan Atlantic Refining Company's exploration well Tucupido No. 1 in December 1946. Initially the well produced 411 bbl of oil a day from the Betty sand at a depth of 5500 ft. The field was developed on approximately 40-acre spacing with a total of 29 productive wells completed in the Betty sand reservoir.

Initial production from the Betty sand reservoir was about 10,000 bbl of oil a day. As of October 1, 1954, after a cumulative total of 6,700,000 bbl of oil had been produced, the reservoir production rate had declined to 700 bbl a day. At that time only nine wells remained on production; the other 20 wells had been shut-in due to high gas-oil ratios or no fluid entry. During this interval the reservoir pressure had declined from an original pressure of 2340 psig to an average of 550 psig.

Cumulative recovery and reserve estimates made at the time indicated an ultimate primary recovery of 7,500,000 bbl of oil or 160 bbl per acre ft. Since these estimates predicted a future life of 15 years would be required to recover the 800,000 bbl of remaining primary reserves, it was obvious that some means of secondary recovery would be necessary to increase the oil rate and ultimate recovery. As a result, it was decided to select an area in the field and install a pilot waterflooding project.

Geological and Reservoir Data

The Betty sand is a lenticular sand composed of upper and lower members in the Roblecito formation of Oligocene age. The monoclinal structure of the formation in the field area dips gently about 1.4 deg to the northeast. Minor faulting in the western portion of the field appears to have had negligible importance in the trapping and accumulation of oil and gas in the Betty reservoir. (See Fig. 2 and 3.)

FIG. 1. Regional Map of Venezuela, South America.

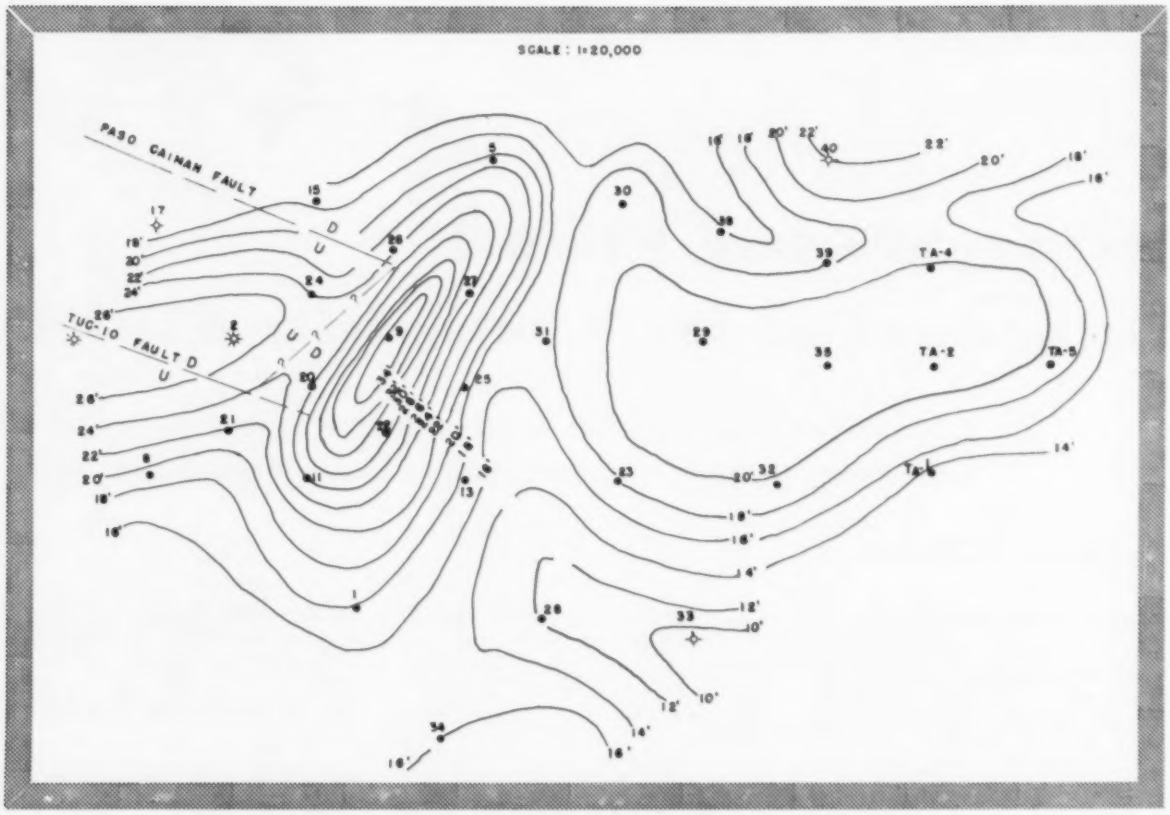

FIG. 2. Betty sand isopach map of gross sand, Tucupido field, State of Guarico, Venezuela.

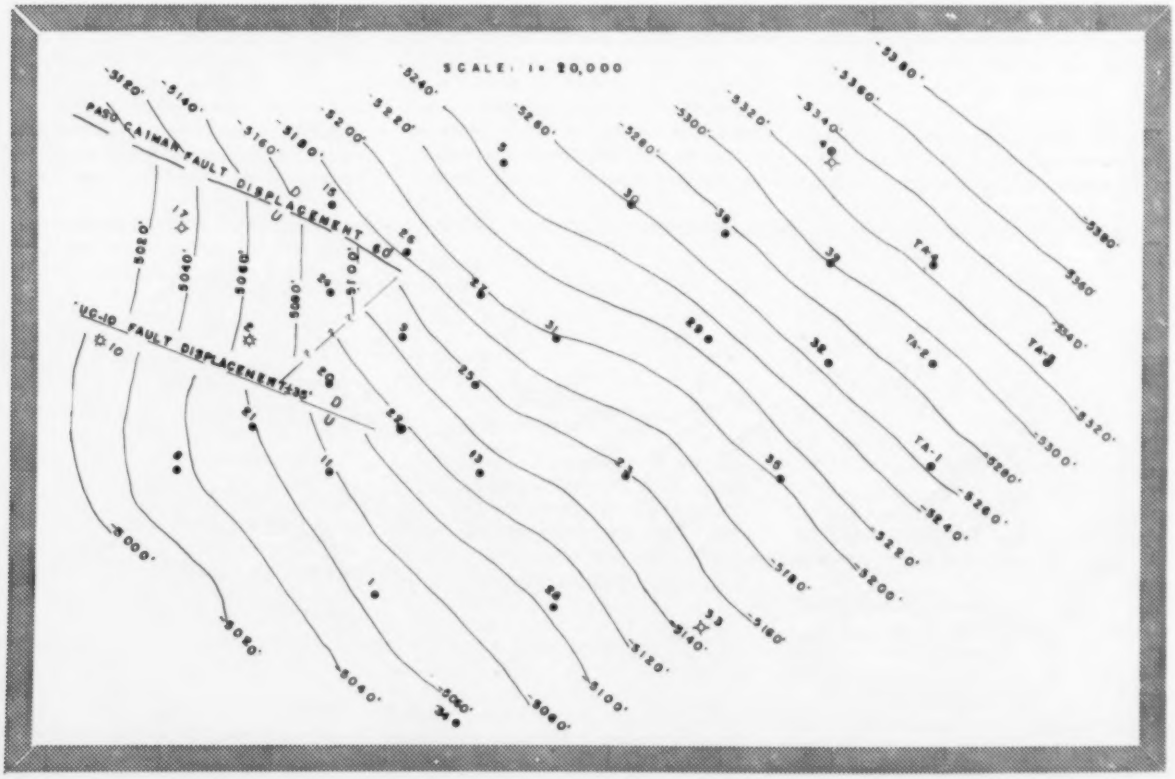

FIG. 3. Betty sand structure contour map on top of sand, Tucupido field, State of Guarico, Venezuela.

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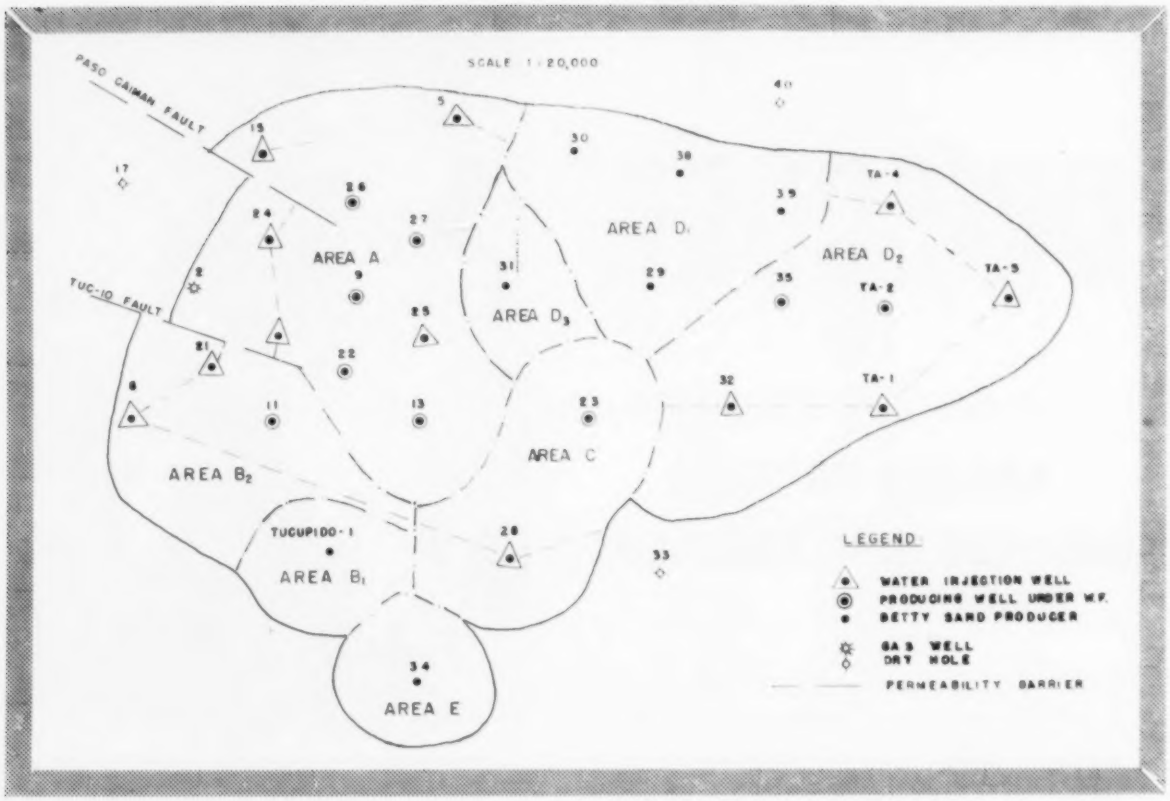

FIG. 4. Flood pattern, Betty sand, Tucupido field, State of Guarico, Venezuela.

From pressure and production data it appears that certain areas in the reservoir are depleting at different rates due to permeability restrictions.

For analysis purposes, these have been defined and designated A, B_1, B_2, C, D_1, D_2, and E as shown by Fig. 4.

A total of 2390 acres were proved productive in the reservoir with an average net sand thickness of about 20 ft. These provide a total reservoir sand volume of 47,000-acre ft in the developed region. Core information indicated the sand to have an average porosity of 18 percent and an interstitial water content of 20 percent. Permeabilities ranged from less than 10 md in the tighter sections to as high as 900 md in the better developed regions.

Under the original reservoir pressure of 2340 psig the 40 deg API oil contained 490 std cu ft per stock tank bbl of solution gas with an initial formation volume factor of 1.49 reservoir vol bbl per stock tank bbl. Volumetric calculations indicated the original oil in place to be about 34,000,000 stock tank bbl.

After it was determined from performance data that the reservoir was producing under solution gas drive, material balance data were prepared that substantiated the in place stock tank oil estimate of 34,000,000 bbl. These calculations also showed that the ultimate primary recovery would be around 7,500,000 bbl or approximately 22 percent of the original oil in place.

Pilot Water Flood D_2 Area

Area D_2 of the Tucupido field was selected for installing the pilot water flood. As shown by Fig. 4, there were six producing wells in this area. Four of the wells were converted to water injection to form a peripheral type drive on two inside producing wells.

Produced salt water from other reservoirs in the field serves as a water supply for the pilot flood. A closed type water injection system capable of handling 6000 bbl a day was installed. The system utilizes a 10 ft by 20 ft horizontal accumulator, two 6 ft by

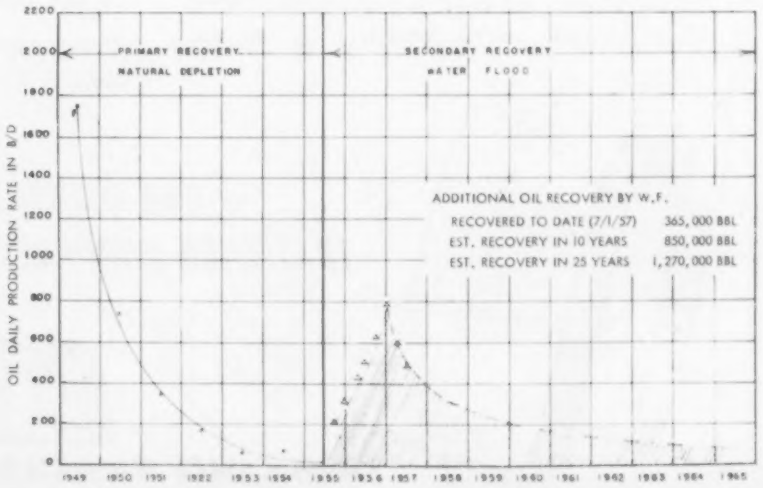
PRIMARY RECOVERY
NATURAL DEPLETION
SECONDARY RECOVERY
WATER FLOOD
OIL DAILY PRODUCTION RATE IN B/D
ADDITIONAL OIL RECOVERY BY W.F.
RECOVERED TO DATE (7/1/57) 365,000 BBL
EST. RECOVERY IN 10 YEARS 850,000 BBL
EST. RECOVERY IN 25 YEARS 1,270,000 BBL

FIG. 5. Pilot water flood D_2 area daily oil production rate, Betty sand.

5 ft filters, a 10 ft by 15 ft horizontal precipitator with a 250-bbl overflow tank, and one 5 in. by 15 in. duplex injection pump. Both the accumulator and precipitator have gas blankets to prevent air contamination. No treating agents are added to the water. The produced water is gathered from the field batteries, filtered, and injected directly into the input wells.

Prior to water injection a total of 1,140,000 bbl of oil had been produced from this area. Only one of the six pilot flood wells was producing at the time water injection was started in June 1955. This well, Taman No. 2, was making less than 30 bbl of oil a day with no water and was retained as a producing well in the pilot. Oil production before and after waterflooding is shown by Fig. 5.

An average of 130 bbl per acre ft or approximately 16.7 percent of the original oil in place had been recovered from the pilot flood area prior to water injection. Material balance calculations in conjunction with flood pot data on cores of the Betty sand indicated the reservoir fluid saturations before flooding, at fillup, and after flooding of the two sand members in the pilot flood area to be as follows:

The Authors

S. L. Chu

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S. L. Chu joined Venezuelan Atlantic Refining Company in 1948 and is now senior reservoir engineer in Caracas, Venezuela. He graduated from Missouri School of Mines in 1947 with a BS degree and did graduate work at Tulsa University in 1948.

E. L. Baldwin joined Venezuelan Atlantic Refining in 1957 and is now resident petroleum engineer in Caracas, Venezuela. Prior to joining Atlantic he served as operations manager with Western Petroleum Development in Tulsa, Oklahoma. He graduated with a BS degree from Tulsa University in 1948 and obtained his masters in petroleum engineering from Oklahoma University in 1950.

FLUID SATURATIONS

Pore Volume Prior to Flood		Pore Volume In Oil Bank		Pore Volume After Flood
		(Upper Member)		
S_{gi} —21.6% S_{oi} —61.4% S_{cw} —17.0%	—Fill Up→	S_{gr} —12.5% S_{ob} —70.5% S_{cw} —17.0%	—Water Flood→	S_{gr} —12.5% S_{or} —26.2% S_{w} —61.3%
		(Lower Member)		
S_{gi} —19.9% S_{oi} —56.6% S_{cw} —23.5%	—Fill Up→	S_{gr} —11.5% S_{ob} —65.0% S_{cw} —23.5%	—Water Flood→	S_{gr} —11.5% S_{or} —27.2% S_{w} —61.3%

If the reduction of oil saturation in the oil bank to the residual oil saturation after flood is used as a measure of unit oil displacement efficiency

$$\frac{S_{ob} - S_{or}}{S_{ob}}$$

then the combined system of both sand members calculates to have an overall displacement efficiency of 59 percent.

Model studies were made of the pilot project to investigate sweep behavior. These indicated a net areal sweep out efficiency of 56 percent would be achieved to an abandonment water cut of 95 percent.

For an estimated 4,860,000 bbl of stock tank oil in place prior to flooding it was predicted from the above efficiencies together with an assumed by-passing factor 0.8 that the pilot project would recover 1,270,000 bbl of oil over a 25-year flood life. For a predicted economic life of 10 years the pilot waterflood recovery will be approximately 850,000 bbl of oil. Based on a floodable sand volume in the pilot area of 8990-acre ft the predicted waterflood recovery averages 95 bbl per acre ft or 14.2 percent of the original stock oil in place.

Water injection was initiated in the pilot in June 1955. At an average injection rate of 3500 bbl a day the calculated fillup volume was reached within about seven months. Reservoir pressure was increased from 500 psig to around 1000 psig.

After 1,800,000 bbl of water had been injectedoil production rate from the two producing wells had increased to an average of 800 bbl a day. However, producing well Taman No. 2 started cutting water only six months after injection started. Naturally channeling was immediately suspected. Using tracers, it was determined that water was channeling from injection

AAODC to ask for Oil Anniversary Stamp

A vote to petition the U.S. Government to issue a postage stamp commemorating the 100th Anniversary of the Petroleum Industry highlighted the first general session of the recent 17th Annual Meeting of the American Association of Oilwell Drilling Contractors in Tulsa, Oklahoma.

The AAODC, in approving the resolution to petition for a postage stamp commemorating the anniversary of the industry "which had its beginning with the drilling and completion of the Drake Well in 1859," joined with "the City of Tulsa, interested citizens and industries" in endorsing the portrayal of a typical scene of a drilling rig in action, as depicted in a "large and beautiful oil painting in the hallway of the Petroleum Club of Tulsa."

The Association says it will "lend its petition to so create a postage stamp to give nationwide commemoration and recognition of such a signal event in the petroleum industry."

In other action at the drilling association meeting, members reaffirmed its "believe in and support of" the 27½ percent depletion provision of the law as it pertains to the oil industry, calling it a "just, equitable and necessary allowance to insure and maintain adequate domestic reserves."

The resolution declared that "a lessening or discontinuance of the 27½ percent depletion allowance which has been deemed wise, equitable and necessary for a very long period of time will greatly retard the discovery of new fields of petroleum and consequently imperil our national defense."

Typical drilling scene proposed for the U. S. commemorative stamp, as portrayed by this painting in the Petroleum Club of Tulsa.

well Taman No. 1. By reducing the injection rate of this well the water cut at Taman No. 2 was immediately reduced and has been maintained at a reasonable level for the past 12 months.

Despite the channeling problem the overall performance of the pilot operation has been satisfactory. As of July 1, 1957, cumulative increased oil due to flooding totaled 365,000 bbl for a cumulative water injection of 1,816,000 bbl of water. Fig. 5 and 6 illustrate graphically the performance of the pilot flood.

For the predicted recovery the investment cost of the pilot flood was $0.20 per gross bbl and the indicated operating and overhead costs will average $0.66 per gross bbl.

Expansion of Pilot to A-B-C Area of Reservoir

In view of the indicated success of the D_2 area pilot flood, the A-B-C areas of the reservoir were developed for flooding and water injection started during April 1957. Inasmuch as these areas have better sand development, it is anticipated that they will respond favorably to waterflooding also.

Eight existing wells in the A-B-C areas were converted to injection as shown by Fig. 4. These together with seven wells retained as producing wells

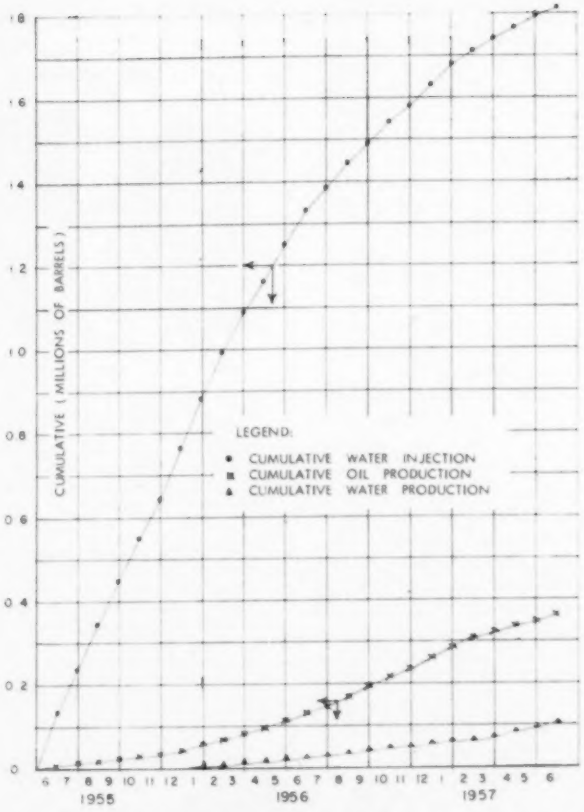

FIG. 6. Pilot flood D_2 area production and injection history, Tucupido field.

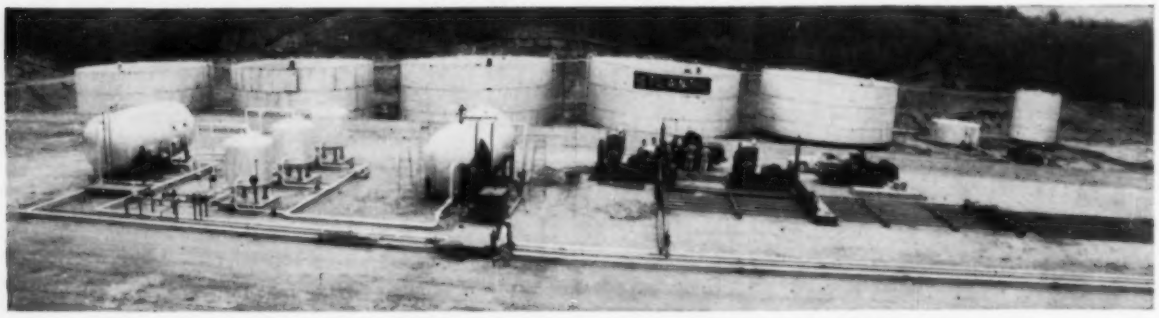

FIG. 7. Water injection facilities and oil storage tanks, Betty sand water flood — A-B-C area.

form an erratic type pattern flood encompassing some 1400 acres.

Closed type injection facilities similar to the pilot flood facilities were installed for processing the injected water. A photograph of the water injection equipment and oil storage tanks for the A-B-C areas is shown in Fig 7. A water supply was developed by gas lifting deep Chaguaramas sand supply wells. Since this source of supply water has proved to be inadequate, it is planned to replace or augment it with water from a shallow supply well equipped with a turbine type pump. With the exception of the addition of a polyphosphate stabilizing agent to the injected water no treating is done. The injection plant is capable of processing 14,000 bbl of water a day for injection.

Prior to flooding a total of 5,200,000 bbl of oil had been produced from the 28,500-acre ft of productive sand in the A-B-C areas. This represents 23 percent of the original stock tank oil in place under these areas. Current oil production had declined to 650 bbl a day from a total of eight wells still producing. From material balance studies which took into account the fluid influx from undeveloped regions of the reservoir, the oil in place at the start of flooding was around 19,300,000 stock tank bbl or 678 bbl per acre ft.

Based on model studies it was predicted that a total of 5,300,000 bbl of waterflood oil would be produced from the A-B-C flood over a 25-year life. However, for a 10-year economic life the predicted recovery is 4,600,000 bbl or 160 bbl per acre ft.

Conclusion

Pilot waterflood performance data indicate that waterflooding in the Tucupido field will result in an increased recovery over primary depletion of 4 to 5 million bbl of oil.

In all probability the operation will be successful both from an economic and conservation standpoint. This venture points out the advisability of carefully screening other oil producing areas in Venezuela for waterflood prospects. ★ ★ ★

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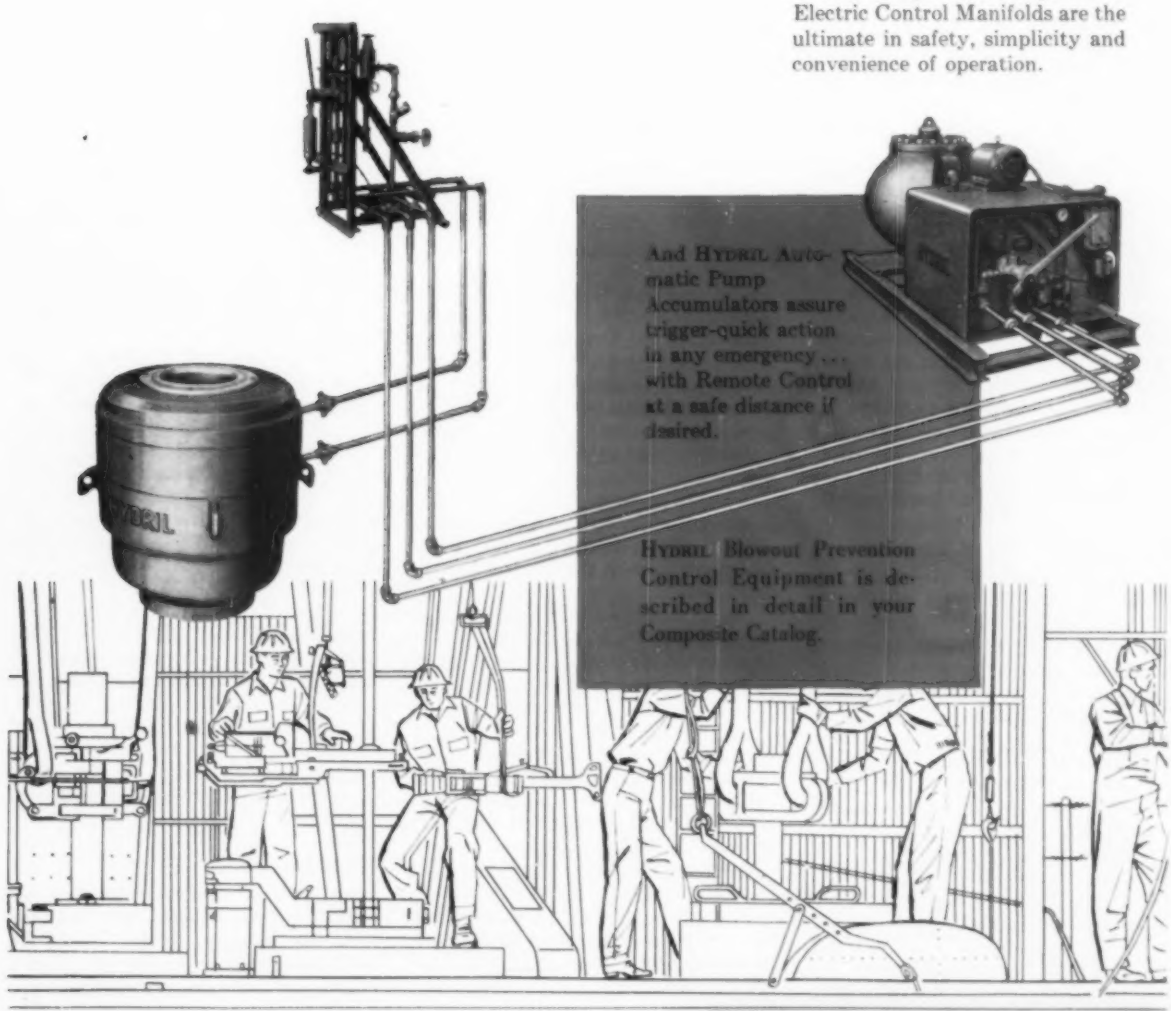
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Here's What You'll Find

If you're going to work in Venezuela

More things are alike than different for employees from the United States in our sister Republic . . . so goes the information from oil companies, supply and service firms

WHEN YOU GO to Venezuela to take a job in the petroleum or allied industries it isn't exactly the same as going to the next state in the United States. But your work itself will be much the same and you won't feel too far from home so far as customs are concerned.

Here we stress the differences only so you can be prepared for them.

Passport

First you get a passport from the Department of State. The post office has applications. Then you obtain a visa from the Venezuelan Consulate most convenient. They are at: Albany, Baltimore, Boston, Cleveland, Chicago, Dallas, Galveston, Houston, Jacksonville, Los Angeles, Miami, Mobile, New Orleans, New York, Philadelphia, Portland, St. Louis, San Antonio, San Francisco, Savannah, Tampa, Canal Zone (Panama), Puerto Rico, and Washington, D. C.

Be sure to get plenty of passport pictures. Get 12 extra copies made to carry with you. Besides passports and visas, you need them for identification documents, driver's licenses, etc.

Physical Examination

Your job offer depends on your passing a thorough physical examination. The members of your family must also provide a favorable medical report for passports if not required by the company.

Traveling

Transportation for you and your family to Venezuela is paid for by the company that hired you. You are expected to travel by the most economical means — which is by plane at present. Excess baggage is frowned on (66 lb of luggage is allowed without charge by commercial airlines) but some companies will pay limited excess. Better check this. Companies using their own planes have individual limits.

Families of new employees usually wait 3 to 6 months before going abroad. Transportation is paid provided employee fulfills contractual obligations.

Airlines between Venezuela and abroad are Pan American, Linea Aeropostal Venezolana, Delta, KLM (Dutch). Good service is maintained and the flight is only a few hours from U.S. points — only 5½ hours between Miami and Maracaibo and 7½ hours between New York and Caracas nonstop.

You won't have any difficulties with customs in Venezuelan ports if you are playing it straight.

After you get to Venezuela most travel is by air. Within the country you can use Avensa, a Pan American associated company, and L.A.V., a government airline.

The country has practically no railroads but highways are being improved and built rapidly so automobile travel is increasing.

You get around the cities by taxi or bus. Buses are usually crowded but a large number of taxis are available. There are no meters on the taxis and it is a good idea to agree on charges before starting.

Climate

Venezuela is entirely within the torrid zone. The climate is tropical in the central plains and in the coastal regions. (This includes Maracaibo.) When trade winds are steady, from early November to late March, daytime temperatures in Maracaibo and the fields are comfortably warm and evenings may be cool. During the balance of the year the weather is hot in daytime, like the middle west United States, but nights are cooler, generally — than this area. Official temperatures are: Low 67; high 98.5, and mean 83 degrees.

Much of the country, however, is mountainous with high plateaus. This means temperate climate between 1800 and 6000 ft. (Caracas is 3000 ft.) Higher sections are cold.

Rather than having summer and winter, Venezuela has a rainy and dry season. It is dry during North American winters, and rains are heavy from May until October.

Clothing

In general, clothing is very expensive in Venezuela, and articles required for the term of service should be purchased before leaving the United States, or other country of origin. For work, persons in Venezuela use the same clothes that would be used in the oil fields in the Southwest during the summer months.

Sport shirts and slacks are suitable for most leisure and social wear. Suits are not used except at semi-formal social events and on some occasions to industry meetings, such as AIME.

In the cities, of course, there are more formal occasions, but social life in smaller centers and camps does not call for dress clothes.

Housing

Where housing is available employees rent houses or apartments. Rent is higher than in United States. In Caracas and Maracaibo rents are from about $200 a month.

In camps living quarters are generally supplied. Bachelors are provided furnished rooms or apartments and married men usually have modern houses. These are built and furnished by the company and a realistic rent is charged. One company charges $30 a month for houses or trailers (furnished) at a production field headquarters.

Air conditioning is available for some company cottages at extra fees.

Most companies incorporate in salary rates for bachelors an allowance of $5 per day for meals. This amount is included in compensation on which a yearly legal bonus of two months is computed. When engineers are required to live away from their usual quarters, the cost of meals normally will exceed $5 per day. Often a company will pay the entire cost of the meals and deduct $5 per day from the employee's compensation.

Food

An effort is being made through the Venezuela Basic Economy Corporation, promoted by Nelson Rockefeller, the oil companies and the government, to reduce the cost of food in the country. Due to these efforts there are a number of independent super-markets in operation, but employees will find that it is more expensive to live in Venezuela than in the United States. Some typical food prices are:

	U.S. Currency
White bread	$ .30 loaf
Rye bread	.30 loaf
Eggs, imported from U.S.	.80 doz
Eggs, local	1.10 doz
Butter	1.20 lb
Hamburger	.75 lb
Filet mignon	1.00 lb
Fresh chicken	1.20 lb
Tinned ham, American or Canadian	1.30 lb
Bacon	1.35 lb
Ice cream	1.20 qt
Sugar	.15 lb
Rice	.19 lb
Coffee—1 lb	1.05 tin
Shortening—3 lb	1.95 tin

Household

You can buy electrical appliances although they are somewhat expensive by U.S. standards, since freight and minor duties have been added to their price, in addition to the high markup which Venezuelan merchants expect. Current is usually the same as in the U. S. A., i.e., 110 v., 60 cycle, a-c. Caracas and some other cities have 110 v., 50 cycle a-c. Clocks don't keep time and record players need adjustment for 50 cycle.

Company houses for oil company staffs at Lagunillas, State of Zulia. — Courtesy Creole

Films, photographic equipment, and sporting goods are also available.

Sears, Roebuck & Company has department stores in Caracas and Maracaibo, which provides a desirable shopping center not previously available. As a result, independent stores are becoming more modernized and competition among first-rate stores is making a healthy business community.

Servants are relatively inexpensive, but you need some Spanish to converse with them. A cook's wage runs from $65 to $150 a month and maids are paid from $50 to $100. All servants are furnished food and usually given medical care.

It can be expensive to receive articles from the States through the mail, as high duties may be added, even on used clothing. This also applies to Christmas and birthday presents, and it is usually advisable to suggest to friends and relatives that they not forward gifts which might subject the recipient to this expense. However, books, magazines, toys and sporting goods usually are subject to very minor duty.

If you consider bringing a car to Venezuela, the four-door sedan has the best resale value, since it can be used later as a taxi. You shouldn't consider bringing other than a new car as markets are very low on old cars. Companies seldom pay any costs for importation of automobiles. It costs $800 to land a new Ford, Plymouth, or Chevrolet. Ample transportation is available.

Currency

Venezuela is one of the few countries in the world which has an adequate supply of dollars, and the local currency, the bolivar (pronounced boh-leé-vahr), is readily convertible into dollars. Most companies pay in dollars for deposit in the United States and cash employees' checks in bolivars if requested. Dollars are not used in Venezuela for marketing, etc.

The bolivar for a number of years has been worth 30 cents in U. S. currency and fluctuations in the exchange rates have been insignificant.

Government and Economics

Government of Venezuela is a Republic headed by a president with two houses of congress. In the past 10 years, the government has changed a number of times, but in all cases, the rights of foreigners and businessmen have been respected.

It is the sixth largest country in South America with an area of 350,000 sq miles, about the size of Texas and Kansas put together. It is made up of 20 states, a federal district (like our District of Columbia) and two territories.

The country is prosperous. The government has instituted many reforms. Right now it is engaged in an effort to attract to Venezuela high-type European immigrants, who, it is hoped, will in time bring into the country more technical knowledge.

The People

The population of Venezuela is largely composed of Spanish, Indian and, to a lesser extent, Negro people. A large proportion are of mixed blood. There is practically no color line. The people are pleasant and friendly.

Total population is more than 6 million.

Spanish is the language and if you expect to live and work in the country the sooner you and your family learn

Spanish the better. There are always classes where you can study the language.

Most Venezuelans are Roman Catholic but freedom of religion is firmly guaranteed and there are Protestant churches serving in Caracas and in oil camps.

U. S. Income Tax

Under the present law and regulations if you are a U. S. citizen who is a bona fide foreign resident during an entire calendar year, you may exclude for U. S. income tax purposes income received as compensation for personal sevices rendered outside the U. S. This generally includes the income earned as a bona fide foreign resident in a broken year before and after the fulfillment of the complete calendar year foreign residenceship.

Since Venezuelan residence requirements cannot be met in a single year, and since most employees are not here for their first year "during an entire taxable year," most persons use the "18 month rule." Under this rule, a U. S. citizen who is present in a country or countries other than the U. S. for at least 510 days during 18 consecutive months may exclude income compensation received for services rendered outside of the U. S., limited to $20,000 for a full taxable year.

The Revenue Department will usually grant an extension for filing the first year's return until the 18-month requirement has been met or full tax year — whichever comes first. In other words, if you are present outside the U. S. for 510 days in 18 consecutive months, you pay no tax on income earned outside the U. S. Travel to and from United States is not included in the 510 days.

Venezuelan Income Tax

Venezuelan income tax rates are considerably lower than those in the U. S. or Canada. However, tax may have to be paid or withheld on items such as the following:

1. Salary and bonus;
2. Living allowance;
3. Freight and duty paid on shipments of personal belongings;
4. Outward transportation expenses for wife and children;
5. Home leave transportation costs.

The tax is relatively small in amount. Here are examples of Venezuelan taxes on selected incomes:

Monthly	*Yearly**	*Yearly Tax*
$400	$ 5,600	$ 50
$500	$ 7,000	$123
$600	$ 8,400	$163
$700	$ 9,800	$236
$800	$11,200	$252

*Includes 2 months legal bonus.

— Courtesy Shell

A scene in one of the junior classrooms of the Venezuelan School (Nicholas Curiel Coutinho) at Cardon, which has 800 pupils.

Venezuelan firms do not pay overtime as such to foreign employees.

Schooling

Public schools are not bilingual and private schools are rather expensive. Oil company camp schools, which go through the eighth or ninth grades, are very good, and fully accredited by U. S. standards. In general, high school students, especially senior high, are educated in the U. S. Some companies pay transportation.

An intense effort to improve educational facilities and the development of two well-supported universities is changing public schooling in Venezuela.

Medical Care

There is no particular health problem for a normal person in Venezuela. A smallpox vaccination certificate is essential for entry into Venezuela and re-entry into the U. S., so that a recent one should be obtained (over three years old not accepted). Also, as a matter of precaution, it is usually desirable to be inoculated against typhoid fever, para-typhoid, and yellow fever.

There is generally no problem regarding tropical diseases, such as malaria and yellow fever. Unless a person is subject to skin infections which might be aggravated by the tropical climate, or finds traveling by plane difficult, he should not be particularly concerned with dangers to his health.

Adequate medical and dental care is available for ordinary purposes. It is usually relatively expensive but is generally paid for by the companies. Oil companies maintain medical facilities at each of their established fields. Hospital costs are in some cases reduced where an employee is able to obtain some reimbursement from a Blue Cross and/or Blue Shield plan in the States. Companies carry compensation for industrial accident or sickness.

There are innumerable instances where Americans have had children born in Venezuela, and medical care and attention have been quite satisfactory. Usually the climate is healthful for children since they can be out of doors all year round.

Recreation

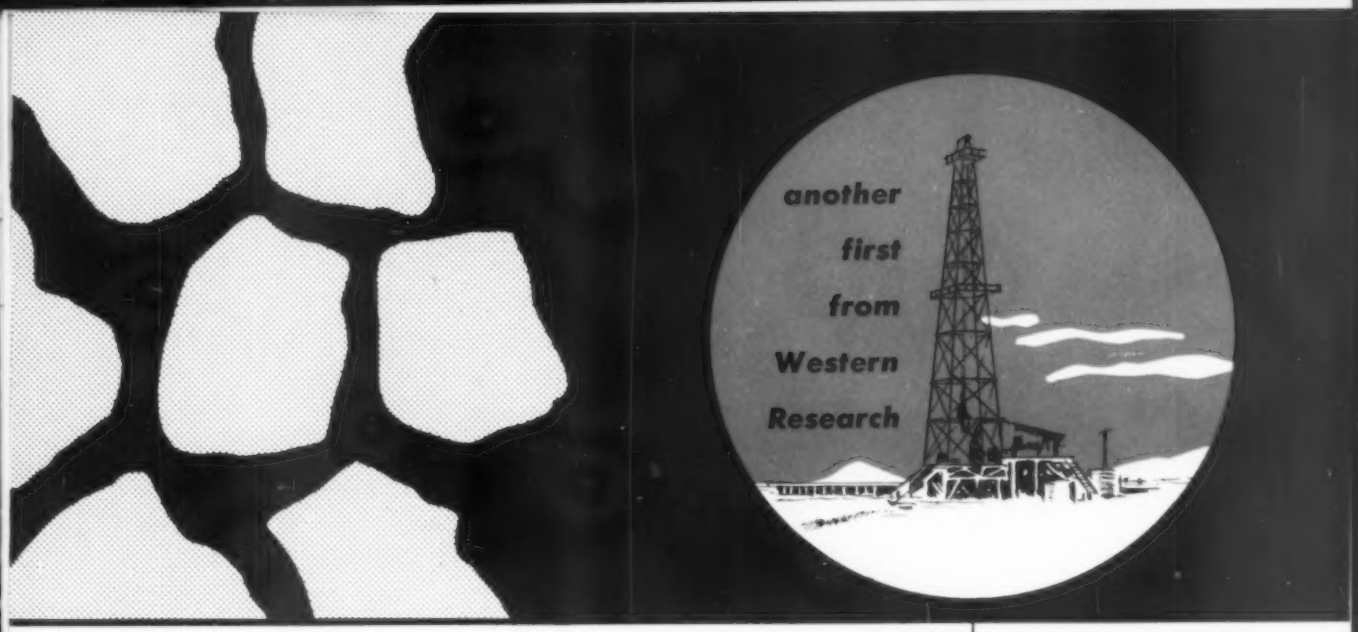
Recreational facilities in the cities are quite good. Movies, radio, television, and concerts are all available. Baseball, soccer, and boxing are popular sports and there are a number of good bowling alleys. Caracas, for instance, is quite close to the coast and weekends of ocean bathing can be arranged.

In addition to the Spanish newspapers, the capital has an English language paper, Caracas Journal, which is published daily and Sunday. All U. S. magazines are available in the local book stores.

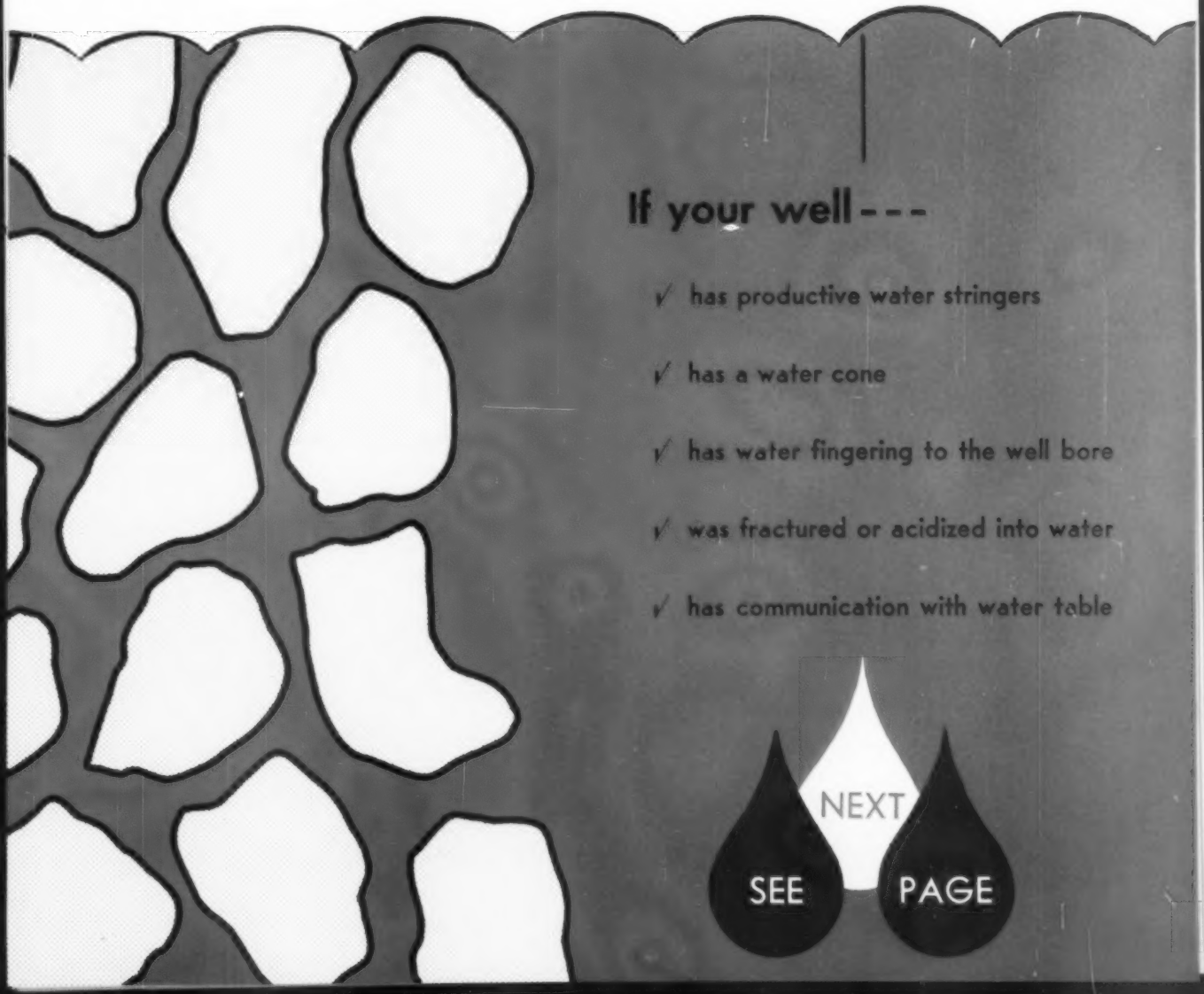
Vacation

Four weeks vacation are allowed for every year of service in the employ of most Venezuelan firms. This amounts to 1¾ to 2 days per month in calculating additional vacation that may be due for months worked beyond the original term of service.

In practice, the vacation allowance is usually broken down into two weeks local leave during the first year, and six weeks home leave and travel time at the termination of a two-year term of service. If an employee completes less than two years service, his allowance for part of a year will be one day for each month of service. ★ ★ ★



SEAL OFF WATER



If your well - - -

- ✓ has productive water stringers
- ✓ has a water cone
- ✓ has water fingering to the well bore
- ✓ was fractured or acidized into water
- ✓ has communication with water table

NEXT
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For the first time, an effective method of selectively reducing or completely shutting off water production in oil wells is now available — Western's Selective Water-Seal Service.

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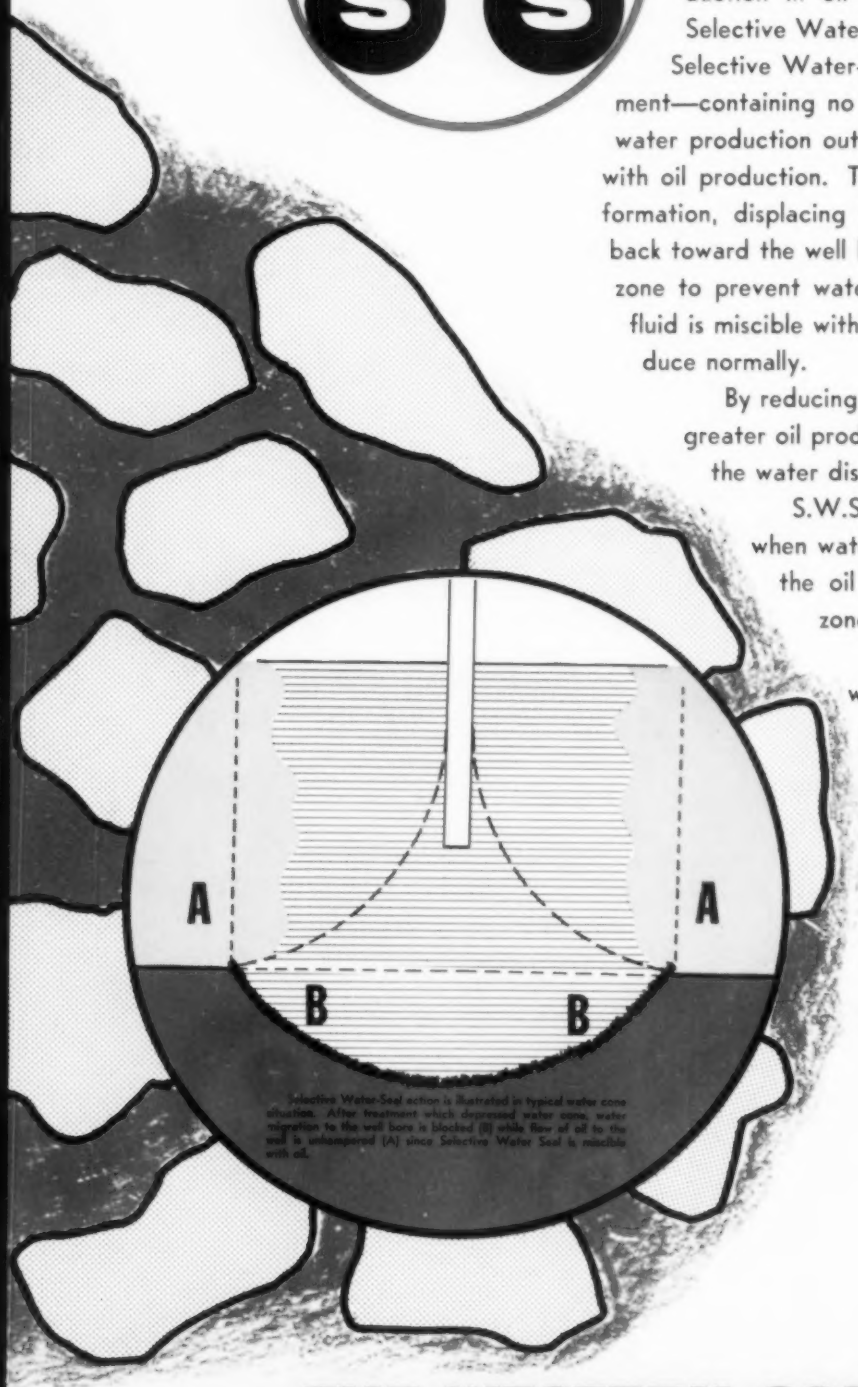
S.W.S. Service is completely selective—when water is being produced separately from the oil in the same zone, or from another zone.

Selective Water-Seal is proved in wells throughout the Southwest. Call your Western Engineer today for more details on Selective Water-Seal, the revolutionary new engineering advance by Western. Or write for information to The Western Company, Box 310, Midland, Texas.



Selective Water-Seal action is illustrated in typical water cone situation. After treatment which depressed water cone, water migration to the well bore is blocked (B) while flow of oil to the well is unhampered (A) since Selective Water Seal is miscible with oil.

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Don Taylor
Gulf Coast Editor

Superior Hits Jackpot in the Lake

Patience, geology and nerve pay off like three bars on a slot machine, and the jack pot may be one of the biggest discoveries in the Western Hemisphere. Over 700 ft net pay logged so far

A BILLION BARRELS OF OIL — possibly much more — appears to be the rich reward for Superior Oil Company's nervy $22 million lease gamble in Venezuela's Lake Maracaibo. Last year the company paid a record $2833 for each of the 7773 acres in a mid-lake lease located beneath 100 ft of water. This price, unprecedented in Venezuela, caused a considerable stir in the oil industry, but it was nothing compared with the excitement that has attended the drilling program which followed.

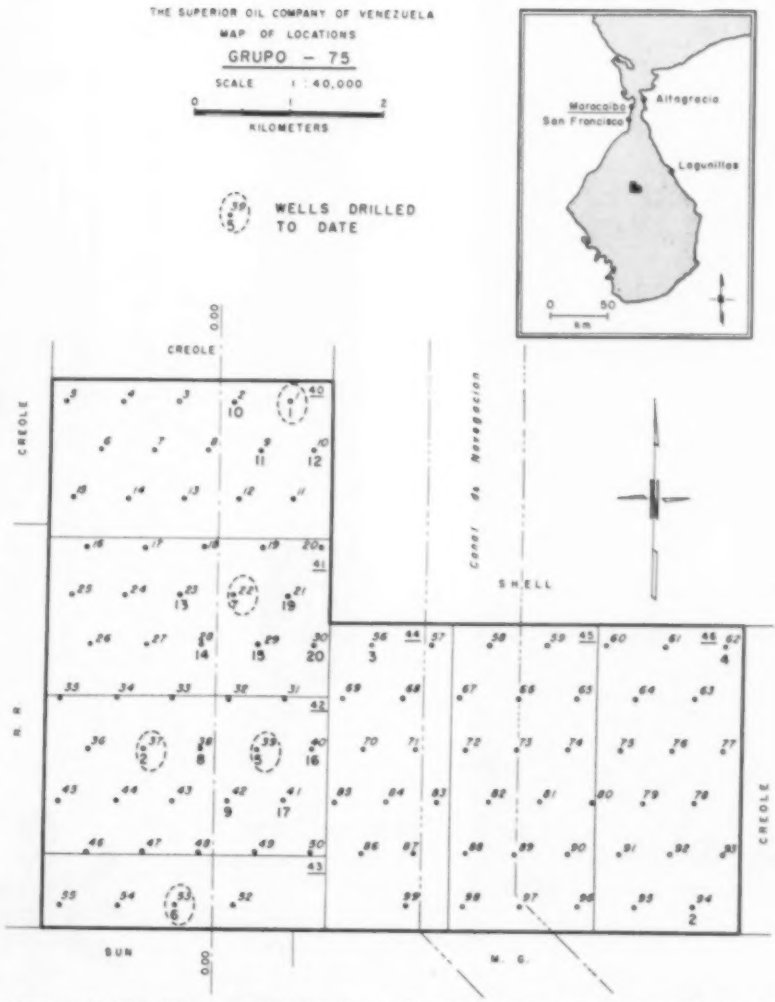
Starting in June, Superior completed three fabulous wells, widely spaced across the stem of its L-shaped, Group 75 lease. Even the poorest of these three wells logged more than 300 ft of major pay sand sections — not counting the numerous thin sand stringers that normally would be included in U. S. well evalutions.

Most exciting of all, however is a fourth well structurally located across a fault from at least two of the wells. This well, known as No. 7 Lama, was still drilling ahead toward its primary target in mid-October when The Petroleum Engineer *went to press. At that time its bore hole had already intercepted more than 500 ft of oil-saturated sand in the Eocene between 7000 and 9000 ft! If the lower target sands that lie below are free of water and have the same massive development as found in the other wells, this well could possibly set a record for total pay zone thickness for a western hemisphere well.*

How does Superior evaluate this field? Company engineers say it is too early to tell for sure. However, they point out that the porosity of the oil sands run from 28 to 34 percent, the permeability from 50 to 2500 millidarcies and gravity of the oil ranges around 30 to 35 API. When you translate these figures in terms of Gulf Coast wells, you would have about 1000 to 1300 bbl of recoverable oil per acre foot. When you consider the great progress now being made in secondary recovery techniques and speculate on the even greater progress that lies ahead during the next 40 years that Superior will be able to produce the wells, these figures seem ultra conservative.

*By taking the smaller figure and multiplying it by the thickness of the major sand sections found in the wells, you have 300,000 to 500,000 bbl of recoverable oil per acre!**

*All estimates of the future reserves of Superior's discovery are those of engineer-author Donald M. Taylor, and are not to be construed as being official pronouncements of Superior Oil Company.



Superior's $22 million concession in the middle of Lake Maracaibo, showing wells already drilled and locations yet to be drilled.

Take a look at the map and you'll see that Superior has already proved up a sizable portion of its acreage with its first four wells; and at this stage, almost any geologist would estimate the reserves at a billion barrels of recoverable oil — possibly much more.

This great discovery was anything but a shot in the dark on Superior's part. For ten years the company had maintained an office in Caracas, Venezuela, despite the fact that it had not a single producing well south of the equator. This project was purely spec-

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PRODUCTION APPLICATIONS

SINGLE ZONE Normal Completion

SINGLE ZONE Permanent Type Well Completions

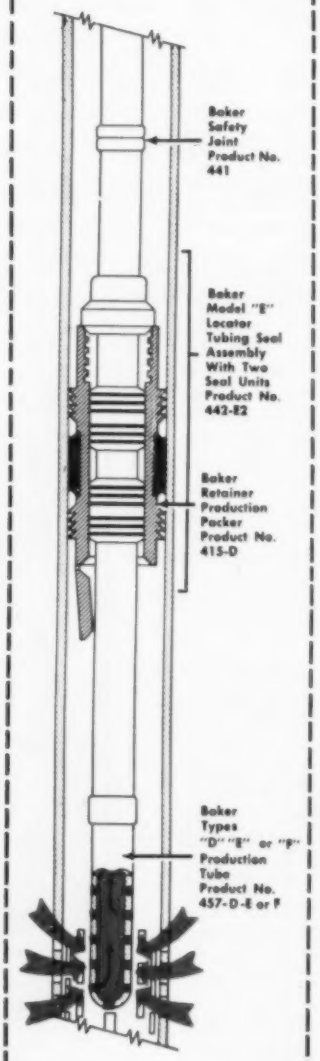
Baker Retainer Production Packer Product No. 415-D

FEATURES

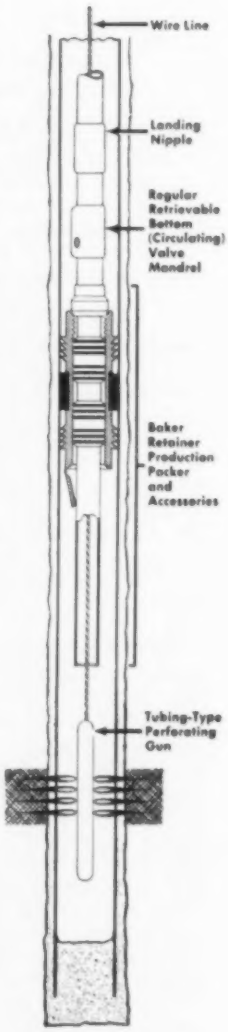
Holds any pressure from either above or below that is safe for the casing, even under temperatures in excess of 300°F.

Pack-off is independent of set-down weight or tension. Tubing string is free; just pick up (or unlatch and pick up) to remove it.

Use it as a squeeze and testing tool or as a temporary or permanent bridge plug in conjunction with any production application.

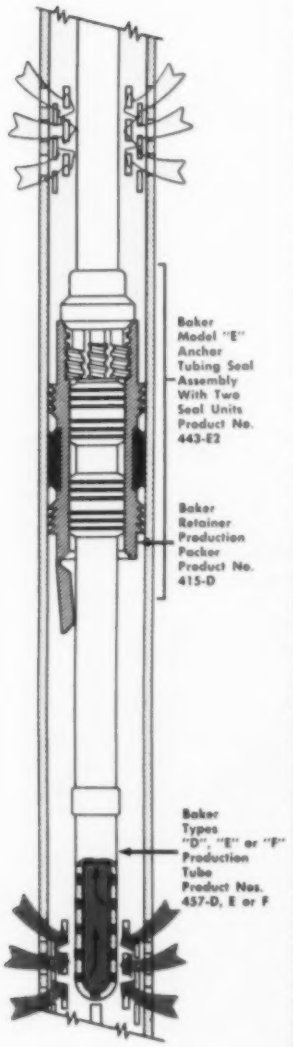

Baker Safety Joint Product No. 441
Baker Model "B" Locator Tubing Seal Assembly With Two Seal Units Product No. 442-B2
Baker Retainer Production Packer Product No. 415-D
Baker Types "D" "E" or "F" Production Tube Product No. 457-D-E or F

Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single-zone production.



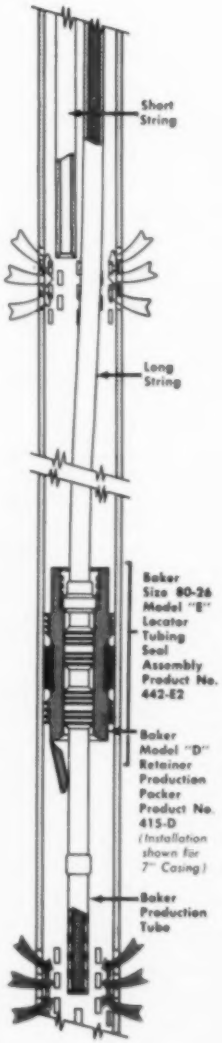
Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the Packer.

DUAL ZONE
Normal Completion


Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Types "D", "E" or "F" Production Tube Product Nos. 457-D, E or F

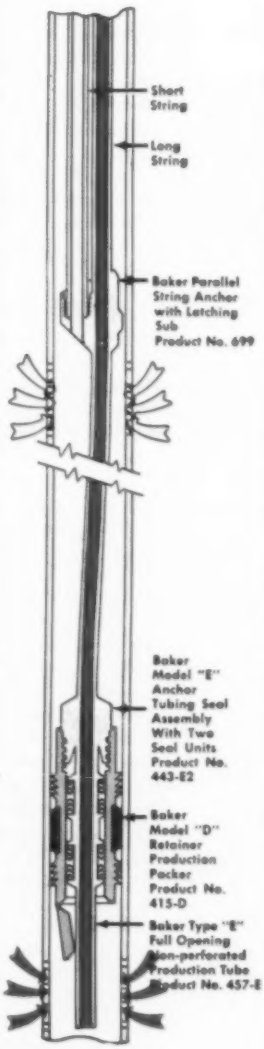
Illustrates Packer set in casing, with anchored production string for dual-zone production. Tubing can be released from Packer by rotating to right.

DUAL ZONE
Parallel String
Short String
Hanging Free


Short String
Long String
Baker Size 80-26 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Model "D" Retainer Production Packer Product No. 415-D (Installation shown for 7" Casing)
Baker Production Tube

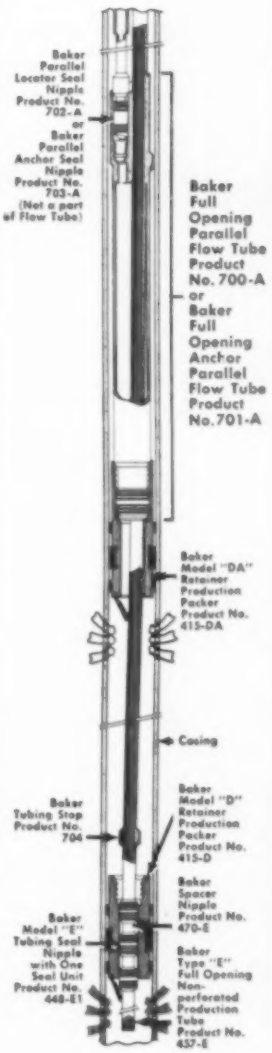
Permits removal of either string independently of the other regardless of sequence. Full-Opening (Tubing I.D.) Long String to lower zone.

DUAL ZONE
Parallel String
Short String
Anchored


Short String
Long String
Baker Parallel String Anchor with Latching Sub Product No. 699
Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Type "E" Full Opening Non-perforated Production Tube Product No. 457-E

Permits removal of either string independently of the other, however long string must be run first. Short string pulled first. Full-Opening (Tubing I.D.) Long String.

DUAL ZONE
Parallel String
Two-Packer Hook-up


Baker Parallel Locator Seal Nipple Product No. 702-A or Baker Parallel Anchor Seal Nipple Product No. 703-A (Not a part of Flow Tube)
Baker Full Opening Parallel Flow Tube Product No. 700-A or Baker Full Opening Anchor Parallel Flow Tube Product No. 701-A
Baker Model "DA" Retainer Production Packer Product No. 415-DA
Casing
Baker Tubing Stop Product No. 704
Baker Model "D" Retainer Production Packer Product No. 415-D
Baker Spacer Nipple Product No. 470-E
Baker Model "E" Tubing Seal Nipple with One Seal Unit Product No. 448-E1
Baker Type "E" Full Opening Non-perforated Production Tube Product No. 457-E

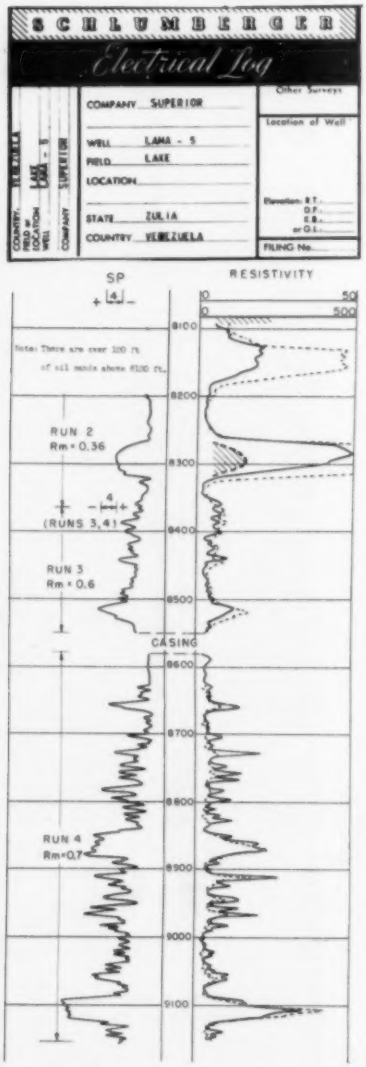
Illustrates Two-Packer parallel string installation with each zone confined to its individual tubing string with full-opening to lower zone for use of all permanent-type completion tools.

ulative aimed at gaining entrance into the Venezuelan oil game. Geologists, geophysicists and seismic crews patiently searched for, and mapped subsurface structures, seeking good drilling prospects that one day might come up for bid.

The cost of this exploratory effort ran an estimated $8 million; *yet there was no certainty that even a single dime of this amount would be recovered.* For one thing, the lands were put up for public bid, and Superior had no means of being certain it would gain control of the leases. However, if an oil company is to progress, it must take risks, striving only to minimize the odds through geology, geophysics and engineering, and this was exactly what Superior was doing.

When the government finally held a sale of a number of lease blocks in its national reserve, Superior abandoned its role of spectator in the giant Venezuelan oil play with relish. Making no pretense of playing its cards close to its vest, it entered a crap-shooters bid — so high there was little chance it would be topped. As it turned out the bid was highest and Superior was awarded a 40-year lease. The blue chip nature of this gamble was augmented considerably by the fact that the concession was submerged in deep water and about as far from shore as you can get in the lake.

Summed up, Superior's total expense on this project at the time Loffland Bros. started drilling the first well from a platform in 98 ft of water in early June probably exceeded $30 million. Moreover, the cost of the wildcats necessary to prove or disprove the prospect likely represented a cash outlay of about $5 million more. *Had the acreage proved unproductive Superior would have sustained a staggering $35 million loss! But, of course, risks of this nature (but not necessarily of this magnitude) are inherent in the oil business.*



This 1050 ft of log of the No. 7 Lama is almost half oil sand. There are numerous sands in the 1000 ft above this section.

Drilling First Four Wells

Operating from concrete pile platforms, Loffland Bros. began drilling the first well on June 26 and a few days later started the second one. The first to spud was No. 1 Lama, in the northeast corner of the block. After setting 200 ft of 30-in. conductor and about 1700 ft of 13⅜-in. surface pipe, Loffland carried the hole to about 8000 ft. Electrical logs supplemented with side wall cores indicated that there was at least 313 ft of well developed oil sands in the Eocene C4X and C5X series. Setting a string of 9⅝-in. casing at 7982 ft, Superior tested and dually completed the well in a 65-ft section of the C4X from 7425-90 ft and a 105-ft section of C5X from 7652-7757 ft. The well tested 5000 bbl a day through a ¾-in. choke.

No. 5 Lama, located 2½ miles south of No. 1 Lama proved even better, logging about 350 ft of oil sands in the Eocene between 7400-8000 ft. No. 6 Lama and No. 7 Lama followed soon after completing a cross section test of the western half of the Group 75 lease (see map). The tests on No. 5 and No. 6 ran about 7000 bbl a day through a ¾-in. choke.

Completion techniques. Superior is completing the wells with an eye toward the future. It is obvious that the productive life of the wells as they stand will last for years; also, there is reason to believe that the wells can be deepened to penetrate additional producing horizons. For this reason, the company has been completing the wells with 9⅝-in. casing. An added advantage of this large diameter pipe is that it provides comfortable working room for dual — even triple — completions that may someday be necessary to maintain an economic production. (As matters stand today, a well must produce at least 200 bbl a day to break even.)

Spacing. For the present, Superior is planning to develop the field on 77-acre spacing, with only one, two or three wells to the platform.

Platforms. Only one well was drilled on each of the first five platforms, but Superior is planning two or three wells per platform in the future. No 6 or 8-well platforms are contemplated. As matters stand today, there is no press to effect small economies. The main problem is to insure a long life and high productive level for the wells. Superior's leases will expire in 40 years and all of the wells will revert to the Venezuelan government.

Superior's first four platforms sit atop conventional concrete piling; the last one utilized an aluminum template, with steel pipe piling. (This was discussed in the October issue of THE PETROLEUM ENGINEER.) The company now has five platforms completed and awaiting drilling rigs and three others under construction.

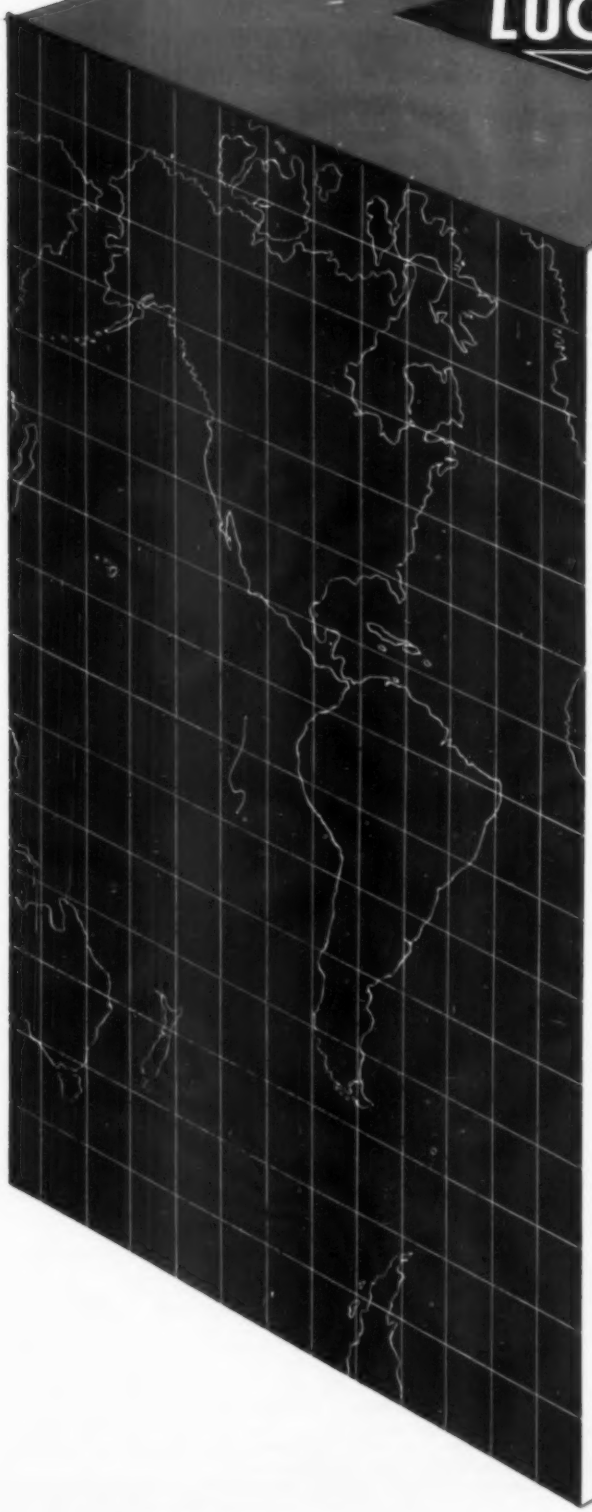
Some years back Superior purchased one of the largest derrick barges ever to operate in the Gulf Coast waters. This barge, known simply as *No. 4* has been towed to the lake for the purpose of erecting platforms and moving drilling rigs. Operated for Superior by J. Ray McDermott Co. crews, this barge is proving highly effective in the lake. On two occasions it has made a complete move — including drilling rig and substructure — from one platform to another in less than one day's time.

Terminal. Superior lost little time in planning auxiliaries to move the oil from the lake to market. The company has just completed a $4 million terminal, with a 1000-ft pier on the western shore of the lake near San Francisco. The contractors for this work were Brown and Root and Raymond Concrete Pile Company.

Pipeline. A 22-mile underwater pipeline running from a gathering system in the lease to the terminal will be constructed soon.

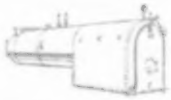
Future. Rarely does an oil company have the good fortune of discovering and developing a reserve of this size. It represents a major accomplishment within the industry, the excitement it generates is felt by all companies operating in the same vicinity. Every additional well in the immediate future will be of keen interest to the entire oil fraternity, because there is a chance that this discovery may turn out to be the greatest of the western world. ★

LUCEY *Export*



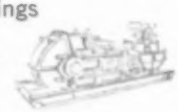
INTERNATIONAL DISTRIBUTORS

of Quality Oil Well Drilling Equipment



Beck "Melloblu" Gas Burners
Byron Jackson Products
Chain Belt Company Sprocket & Roller Chain
Hughes Rock Bits and Tool Joints
Lucey Boilers and Insulation Casings

Mission Pistons, Liners, and Valves
Parkersburg Derricks, Brakes, and Tanks
Pittsburgh Steel Oil Country Tubular Goods
Reddaway Brake Blocks and Linings
Reed Rock Bits and Tool Joints



Security Engineering Products
Thermactor Electric Oil Well Heaters
Totco Drift and Directional Recorders
Union Wire Rope and Tuffy Slings
Wheland Rotary Drilling Equipment

LUCEY *Export*

LUCEY EXPORT CORPORATION

233 BROADWAY, NEW YORK 7, N. Y.

Pretecca, Urbanizacion Sucre, Maracaibo, Venezuela
Calle Defensa 320, Buenos Aires, Argentina
Broad Street House, London E.C.2, England
Rua do Carmo, 8-7º, Rio de Janeiro, Brazil
Calgary and Edmonton, Alberta, Canada
West Building, Houston, Texas

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

You Can Buy It in Venezuela

With growth of oil operations, supply houses and service companies began moving into the area . . . More and more materials and equipment are bought on the spot . . . These are the companies, their locations and their personnel

OIL COMPANIES' dollars buy more in the United States than in Venezuela because the exchange rate is slightly stacked against them. They receive fewer bolivars in exchange for dollars than the regular rate (1 bolivar = 30 cents free exchange).

This is actually another tax on the oil industry and in some ways it hinders development of on-the-spot equipment stores and servicing. Oil companies followed the same pattern they did in the United States 30 years ago. They were forced to build up large expensive inventories. Time was lost because the right part wasn't near the place it was needed. Engineers with the oil company serviced equipment without the highly specialized training of supply company engineers.

Every company management, questioned about where its purchases were made, said that staff members bought all they could from local supply stores. Several said they'd be pleased when materials like pipe were stocked by supply houses in Venezuela.

Here is an actual demonstration of the money value of supply company stores and service. The Venezuelan oil industry finds it pays to buy from companies in the field although the fixed exchange rate makes supplies cost more locally. Savings on inventories are large and consultation and service provided by equipment company engineers means more efficient operations.

Supply and service companies are setting up sales offices and stores at a rapid rate in those parts of Venezuela where there are oil and gas operations.

For that reason our directory will be continued next month to bring the list as up to date as possible. Both parts will be reprinted for use by Venezuelan petroleum companies.

Supply and Service Companies in Venezuela

A-Z EXPORT, S. A.

Distributors for: IDECO Div. of Dresser International, Inc. (drilling masts; sub-structures; drive-in rambler rigs; swivels, rotaries; mud pumps, petroleum equipment and supplies.) H. C. Smith Oil Tool (rock bits and hole openers).

Maracaibo: P. O. Box: Apartado 304*. Cable: AZEXPORT. J. E. Berry, manager.

Puerto La Cruz: P. O. Box: Apartado 4026. Cable: AZEXPORT. Granville Berry, manager.

BARITINA DE VENEZUELA, S. A.

Distributors for: Baroid Division (National Lead), Oil Base, Rayonier Export, Sonneborn Inter-American, Atlas Powder.

Local manufacturers of Baroid with grinding mills at Punta Camacho, Estado Zulia and Pamatacualito, Estado Anzoategui.

Complete drilling mud service available.

Caracas: Edif. Internacional, 3rd floor, Offices 1 and 2, Urapal a Rio (Avenida Urdaneta). Telephones: 54.62.91 and 54.62.56. P. O. Box: Apartado 9117. Cable: BARVENSA. Morgan Leonard, general manager; George W. Crocker, assistant manager; John H. Simons, western division manager; G. Harden Plowman, eastern division manager.

Puerto La Cruz: Carretera Negra, Edo. Anzoategui. P. O. Box: Apartado 4097. Telephone: 2115.

Anaco: Edo. Anzoategui. Robert Bates, Richard K. Newman, and Austin McComb.

Maracaibo: Calle San Loreto 16-93, Edo. Zulia. P. O. Box: Apartado 162. Telephone: 5671. Sam Ezell, Jr.

Las Morochas: Edo. Zulia. Eric Freeman.

Barinas: Edo. Barinas. José Carrero.

Maturin: Edo. Monagas. Jack Roland.

BYRON JACKSON TOOLS, INC.

All B-J drilling tools are sold except cementing equipment.

Maracaibo: % Oilfield Sales and Service, S. A., Apartado 749. Telephone: 7-0901. John Hankins.

CLARK BROS. PAN AMERICAN Div. of Dresser International, Inc.

Engines and compressors-gas, steam or diesel engine-driven types for the oil, gas, and chemical industries.

Caracas: Edif. Radio Continente, 6° Piso Oeste, Ave. México, Los Caoboes. Telephone: 553-651. Cable: CLARKO. T. C. Webb, Jr., manager.

CIA. HALLIBURTON DE CEMENTACION Y FOMENTO

Maracaibo: (Division Office)— P. O. Box: Apartado 238. V. V. Gunn, president; H. N. Pranglin, assistant manager and division engineer, K. V. Jenkins, secretary-treasurer. (District Office) — M. W. Wilson, district superintendent, S. S. Ferrell, Jr., assistant district superintendent.

El Tigre: (Division Office) — P. O. Box: Apartado 226. R. L. Gee, manager of operations, B. S. Stroshine, assistant manager, testing and special tools. (District Office)—P. O. Box: Apartado 238. C. C. Oekerman, district superintendent, L. R. Miller, assistant district superintendent.

Western Venezuela (Operating locations.)

Maracaibo. P. O. Box: Apartado 238.
Las Morochas: % Apartado 238, Maracaibo.
Barinas: % Apartado 238, Maracaibo.
El Tigre. P. O. Box: Apartado 226.

Eastern Venezuela (Operating Locations.)

Anaco. % Creole's San Joaquin Camp. P. O. Box: Apartado 35, Barcelona.
Las Mercedes: % SAPLM Roblecito Camp. P. O. Box: Apartado 1429, Caracas, D. F.
El Tigre: P. O. Box: Apartado 226.
Jusepin: Jusepin, Monagas.

CONSTRUCTORA RAYMOND C. A.

Contractors (refineries—power houses—docks—oil installations).

Caracas: Edif. Sudameris, Avenida Urdaneta y Avenida Fuerzas Armadas. P. O. Box: Apartado 1846. Telephone: 54-55-81. Robert B. Finlay, manager.

Maracaibo: Edif. Obispo Lazo, Calle Obispo Lazo. P. O. Box: Apartado 161. Telephone: 4725. David K. Smith, manager. (Complete construction service to the oil companies.)

CONTINENTAL-EMSCO COMPANY, C. A.

A Venezuelan corporation (Youngstown Sheet and Tube) handling complete sales and service facilities for all types of oilfield machinery and equipment.

Caracas: Edif. Galipan, Apt. A. (P.O. Box:) Apartado del Este 5122. Telephone 32750. Cable: CONEMSCO. William G. Sharp,

*"Apartado" means P. O. Box but sometimes it was repeated as explanation.

manager; JoEarl Morris, assistant manager; Ike Ridenhour, sales engineer.

Maracaibo: Sales office — Hotel del Lago. P. O. Box: Apartado 90. Edo. Zulia, Venezuela. Telephone 5769. Harold Hann, sales engineer. Store — P. O. Box: Apartado 90. Edo. Zulia. Telephone 5769. Cable: CONEMSCO. John Aston, store manager.

Anaco: Store — Puerto la Cruz. Apartado 4204. Edo. Anzoategui. Cable: VENMEX, Puerto la Cruz. J. R. Stebbins, store manager.

Las Morochas: Store — Las Morochas. Edo. Zulia. Distrito Bolivar. Cable: CONEMSCO, Las Morochas. G. N. Frost, store manager.

CORE LABORATORIES DE VENEZUELA, S. A.

Core analysis, well (mud) logging, reservoir fluid studies, special core analysis.

Maracaibo: Company and sales office — P. O. Box: Apartado 116. Telephone: 73288. Ernest Allen, Jr., manager.

Cabimas, Zulia: Western district — Core analysis, well (mud) logging, and reservoir fluid studies. Thomas O. Wood, supervisor.

La Canada: Core analysis.

Anaco: Eastern district — Core analysis, and well (mud) logging.

EAST-WEST OILTOOLS, C. A.

Distributor for: Bettis Rubber Company, The Parkersburg Rig and Reel Company, Oil Center Tool Company, Goodyear Industrial Products, Milwhite Mud Sales, Universal Packing & Gasket Company, Tretolite Company, Otis Gas Lift & Valves, Harbison-Fischer Company.

Sales of oil field specialties and supplies, tubular service and testing, complete drilling mud-chemical sales and service.

Maracaibo—Western Venezuela: Main Office—Warehouses— Service, Hotel del Lago, Apartado 273. Telephones: 77.715, 76.611 (Ext. 173). Cables: EASTWEST MARACAIBO. J. B. Harder, R. C. Thompson, Pat Patterson, and T. P. Dwyer.

Anaco—Eastern Venezuela: Office — Warehouse — Service. Apartado 4158, Puerto La Cruz. Telephone: 86.374 W. N. Thornhill, C. L. Smith, H. Baycroft, M. Quattlebum.

Las Morochas—Office—Warehouse: Telephone: Creole Tia Juana 4502. H. Toledo, L. B. Turman.

GEOMARINE SERVICE, INTERNATIONAL, S. A. (GSI)

Caracas: Edif. Desire, Calle Madrid, Urb. Las Mercedes. Telephone: 36-629. Cable, GSI. Calvin J. Spivey, manager.

GUIBERSON CORPORATION (DRESSER INDUSTRIES)

Sales, service and applications of Guiberson products.

Las Parcelas de Anaco: Estado Anzoategui. Telephone: 86-253. M. W. Breedlove, service engineer.

Maracaibo: 17-19 Avenida 16. Telephone: 72-373. James W. Dahline (represents Beckley, Haltom and Hickman directly).

LUFKIN FOUNDRY & MACHINE COMPANY, INTERNATIONAL OF VENEZUELA

Sales and service facilities for pumping units, engines, speed reducers, speed increasers and marine gearing.

Maracaibo: Sales and warehouse offices, Av. 17, Los Haticos No. 128-60, Apartado 93, Howard Hogue, manager.

Anaco: Warehouse in process of being installed.

MAGCOBAR DE VENEZUELA, C. A.

Specialized drilling mud products.

Caracas: 4° Piso, Edif. Luz Electrica, Ave. Urdaneta. P. O. Box, Apartado 3775. Telephone: 54-35-41 to 54-35-48. Cable: MAGCOBAR. Ten Eyck Hull, manager.

J. RAY McDERMOTT & CO., INC.

Marine oilfield construction contractors.

Maracaibo: Edif. El Globo. P. O. Box: Apartado 559. Telephone: 2431-2-3-4. Robert K. Richie, principal engineer; Gilbert C. Patton, superintendent; Leland C. McElroy, office manager. Officers: Roger W. Wilson, president, C. L. Graves, vice president and manager; Thomas P. Hull, Jr., secretary; Leland C. McElroy, assistant secretary.

MID-CONTINENT SUPPLY CO. OF VENEZUELA, C. A.

Oilfield supplies of all kinds.

Caracas: Apartado del Este 4414. Telephone: 55-0594. J. W. Davis, Venezuelan manager, J. C. Ellison, Jr., Venezuelan machinery manager.

Anaco: % S. A. Ven Mex, Apartado 4087, Puerto La Cruz. G. S. Durbin, store manager; C. N. Epperson, office and warehouse manager; B. H. LeNorman, field sales; J. R. Martin, field sales.

Maracaibo: Apartado 605. Telephone: 7-7713. O. G. Garner, manager; J. E. Weems, field sales, W. P. Brandon, field sales; A. J. Covaleski, office and warehouse manager; W. L. Rosenbach, stock control supervisor.

OFICINA TECNICA STUBBINS, C. A.

Distributors for: Cardwell Manufacturing Company (oilwell drilling and servicing equipment). Branch offices carry a stock of parts for Cardwell units.

Caracas: Home office — Apartado 7. Telephone: 429.111, 429.116. John R. Stubbins, administrator. Gabor Morvay, manager of sales. Jules Haltenberger, district manager.

Puerto La Cruz: Apartado 4072. Telephone: 1146. J. F. Rone.

Maracaibo: Apartado 162. Telephone: 3440, 6776, 6777, 6778. Charlie Gottling, sales contact.

Distributors for: Dresser Manufacturing Div. Dresser International, Inc. (pipe couplings, fittings, repair clamps and sleeves).

Caracas: Colon a Dr. Diaz No. 23. P. O. Box: Apartado No. 3974.

OIL METERING AND PROCESSING EQUIPMENT CORP.

Maracaibo: Edo. Zulia, Venezuela. P. O. Box: Apartado 304. Telephone: 7-7460. Cable: YETCO. Norman E. Yett, Norman E. Yett & Associates, C. A. (sales and service representative).

Puerto La Cruz: Edo. Anzoategui. P. O. Box: Apartado 4072. Telephone: 2222. J. Leslie Rowell, Norman E. Yett & Associates, C. A.

PACIFIC PUMPS, INC. Div. of Dresser International, Inc.

Oil well plunger pumps.

Caracas: Edif. Galipan. P. O. Box: Apartado 4607 Este.

PETROLEUM INDUSTRY CONSULTANTS, C. A.

Distributor for: Oil Well Supply, Merla Tool.

Caracas: Edif. Luz Electrica de Venezuela, Avenida Urdaneta. P. O. Box: Apartado 3992. Telephone: 54-55-51. G. M. Davies, manager.

Stores:

Anaco.
Maracaibo.
Barinas.

PETRO-TECH SERVICE, C. A.

Venezuelan Lane-Wells (Dresser Industries). Offers all of Lane-Wells services and products and also Dia-Log Free Point indicator and back-off services and other miscellaneous fishing services.

Caracas: Edif. Galipan, Urbanizacion El Rosal. P. O. Box: Apartado 2728. Telephones: 38.805, 32.854. John M. Miner, president, (telephone — 35.976); Robert S. Hall, secretary-treasurer (36.176); W. B. Ballew, manager of operations, (38.117); Jay G. Beaver, sales manager, (36.047); Russell G. Norelius, chief logging engineer, (33.691); R. A. Hancock, chief field service engineer; B. J. Patin, materials supervisor, (33.635); Harold H. Holmes, chief accountant; James J. Corboy, controller.

Eastern Division

El Tigre: Camp, Edo. Anzoategui, P. O. Box: Apartado 174, M. G. O.: 83.191. Stanley C. Weiss, manager; T. G. Gover, assistant manager; Ken Larson, division field service engineer; D. M. Smith, superintendent, 83.391.

Anaco: Edo. Anzoategui. M. G. O. 86.239. W. C. Bates, superintendent.

Jusepin: Camp, Edo. Monagas. M.G.O. 87.450, 87.451. Edward J. Fetsch, superintendent.

Las Mercedes: Las Mercedes district — S. A. Petrolera, Las Mercedes, Edo. Guarico. SAPLM 95. Nevelle B. Warren, superintendent.

Western Division

Las Morochas: Petro-Tech Camp. Edo. Zulia. P. O. Box: Apartado 677. M.G.O. 77.220, Creole 3.600. H. H. Hittson, manager; W. H. Ingram, assistant manager; Lee Daniels, division operating engineer; E. L. Sartain, superintendent.

Maracaibo: Quinta Matilde, Avenida El Paraiso, Urb. Grano De Oro, Edo. Zulia. P. O. Box: Apartado 677. Office: 4.520, residence 4.341. R. V. Dickeson, superintendent.

Barinas: Sinclair Camp, San Silvestre, Edo. James O. Landrum, superintendent.

(Directory will be concluded in December)

To Be Continued Next Month

Second and final part of this Venezuelan Supply and Service Directory will follow in December. This will permit those companies who have not yet sent in their information to do so for inclusion in Part 2.

Reprints To Be Available

Upon completion of the Venezuelan Supply and Service Directory in December, reprints will be available without charge upon request.

Deeper Drilling Emphasizes Importance of...

A High-Temperature Oil Well Cement

I. R. Dunlap **F. D. Patchen**

Magnolia Field Research Laboratory
Magnolia Petroleum Company, Dallas, Texas

At depths greater than 15,000 ft and at bottom-hole temperatures exceeding 300 F, a cellulose derivative (CMHEC) has exceptional retarding properties, and maintains low slurry viscosity for extended periods

LABORATORY tests and field applications of CMHEC (carboxymethyl hydroxyethyl cellulose) have revealed that this compound has an excellent retarding effect upon slurries of common portland cement. Small amounts of CMHEC effectively retard the setting rate of all portland cements tested, even under severe conditions of temperature and pressure. Quantities as little as 0.4 weight percent CMHEC (based on dry cement) have been found to sufficiently retard the initial set of most Class A cement slurries over the full 18,000-ft depth schedule (API-RP 10B) as obtained in the high-pressure consistometer. Other slurry and set cement properties such as viscosity, density, fluid loss and compressive strength have also been found to be good. Significant increases in early compressive strengths of samples cured above 300 F can be obtained through the addition of moderate amounts of finely ground silica. Furthermore, strength retrogression with time at high temperatures is also eliminated by such additions.

CMHEC-portland cement mixtures have been used successfully for the cementing of production casing and in plug-back and squeeze cementing operations. This special cement has been used in several bore holes from 10,000 to 21,600 ft in depth and over a temperature range of 200 to 380 F. The slurries were prepared with conventional equipment and techniques; excellent pumping characteristics and adequate set cement strengths were obtained in all field applications. These pronounced advantages of CMHEC-retarded slurries over regular oil well cements are obtained at negligible increases in operational costs.

Need has been acute. In recent years, the problems associated with the drilling and completing of deep wells have become increasingly important to the oil production industry. With respect to oil well cementing, the need has been acute for retarded cements that can safely be placed at depths greater than 15,000 ft when bottom-hole temperatures exceed 300 F.

Of the several classes of chemical compounds that act to retard the initial set of portland cement slurries, those derived from cellulose are of special interest because of their thermal instability. It might be expected that any retarding action of a cellulose derivative would be thermally sensitive, that is, the retarded slurry would remain fluid for long periods at low temperature, but would thicken and set as the molecular structure of the retarder was altered at higher temperatures. Such is the case, although a considerable variation in retarding efficiency exists among the common cellulose derivatives. Of these, carboxymethyl hydroxyethyl cellulose (CMHEC) has been found to possess exceptional retarding properties, being 2 to 5 times as effective as other cellulose derivatives such as carboxymethyl cellulose (CMC) or hydroxyethyl cellulose (HEC).

Composition of CMHEC-Retarded Cements

The cements discussed contain portland cement as the principal component. Either API Class A construction cement (ASTM Type I) or the coarser grind oil well cements (API Class D or E) can be used. Small variations in properties will result from the choice of the base cement.

Viscosity control. CMHEC is added to control the slurry thickening time. Several grades of CMHEC are available. As will be shown, small differences in retarding efficiency exist between different grades. More importantly, the initial viscosity of the slurry depends markedly on the grade of CMHEC, particularly when the retarder concentration exceeds 0.5 weight percent of the cement. In determining the optimum composition, a compromise must be reached between retarding efficiency which slightly favors high viscosity grades, and initial slurry viscosity, which heavily favors the lower viscosity grades. The amount of CMHEC in a particular oil well cement is determined by the anticipated pumping schedule.

Setting strength. The set strengths of all neat portland cements vary considerably with curing temperature. At temperatures above 250 F, early set strengths are reduced and these initial

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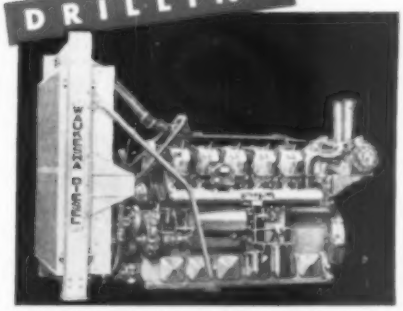

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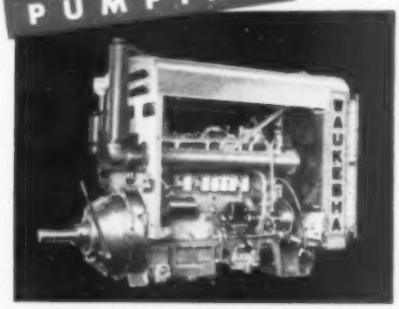

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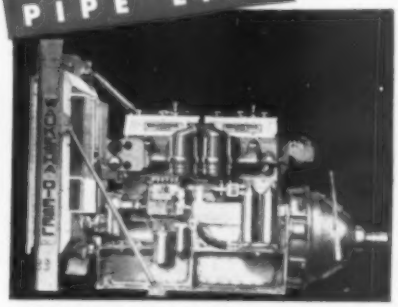

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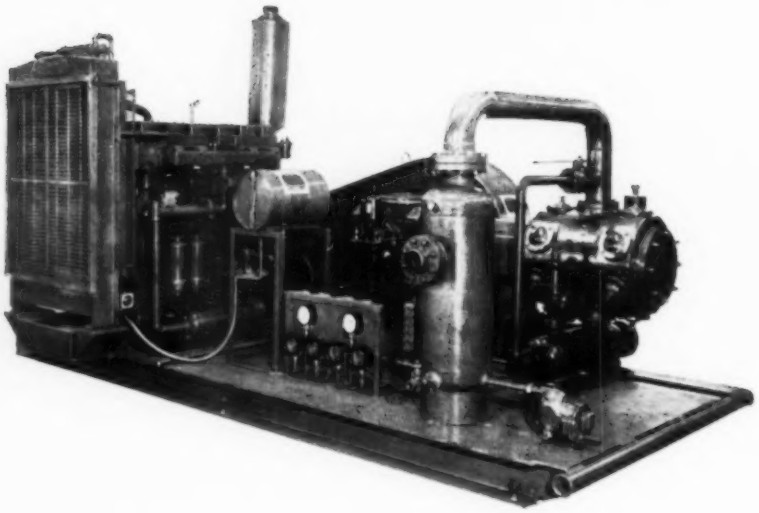

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strengths tend to retrogress when the cement is maintained at high temperatures.[1,2] It has been shown that this lower early strength and subsequent retrogression can be eliminated in portland cements by moderate additions of finely ground silica.[3] None of the other cement properties are adversely affected by such treatment. For any given base cement, some optimum ratio of silica to cement will yield maximum early set strength. For most practical applications a ratio of about 3 parts of silica to 10 parts of cement imparts high early strength and eliminates retrogression when curing is carried out at temperatures between 250 and 350 F.

CMHEC-treated cements containing finely ground silicas have densities of the order of 15 to 16 lb per gal. They may be easily weighted to the order of 17 to 18 lb per gal with ordinary oilfield barite without significant changes in the other slurry properties.

In summary, the constituents of the high-temperature oil well cement discussed in this article are: (1) A base portland cement, either Class A or a coarser grind oil well cement, (2) CMHEC to retard early thickening time, (3) finely ground silica to increase 24-hr set strength and eliminate retrogression, and (4) barite in amounts necessary to provide the desired density.

TABLE 1. Thickening Times and Set Strengths of CMHEC Retarded Class A Cements (Without Silica Flour) and Regular Oil Well Cements.

Base Cement Cement Class & Brand	Weight Percent CMHEC	Thickening Time to 100 Poises High Pressure Consistometer (14,000 ft)	(16,000 ft)	(18,000 ft)	24 hr Compressive Strength (psi) (180 F)	(260 F)	(290 F)	(320 F)	(350 F)
		1:24*	1:31*	1:40*					
Class A**	0	0:55	0:46	0:40	5400	4500	5500	5000	3300
Brand I	0.1	2:30	1:25	—	2842	4400	5100	3750	2250
	0.2	5:00	2:03	1:13	970	4140	4800	2200	1980
	0.4	—	3:19	1:44	N.S.	4000	4540	2430	1680
	0.5	—	3:56	2:00	N.S.	3990	4400	2300	1650
	0.8	—	—	2:43	N.S.	3830	4150	2000	1520
	1.0	—	—	3:03	N.S.	3770	4000	1870	1483
	1.5	—	—	3:35	N.S.	—	—	1500	1288
Class D***									
Brand II	0	2:02	—	—	1797	4533	—	—	—
Class E***									
Brand III	0	2:27	1:30	—	2440	—	2482	—	—
Brand IV	0	2:58	1:35	1:16	2179	—	5270	—	—
Brand V	0	3:34	1:34	1:20	2088	—	4329	—	—

*Minimum pumping times — API-RP 10B.
**ASTM Type I.
***Commercial oil well cement.
N.S. — No set in 24 hr.

LABORATORY DATA

Slurry Thickening Time

The effect of CMHEC on the thickening time and set strength of Class A portland cement is shown in Table 1. From the high-pressure consistometer data it is seen that small amounts of CMHEC greatly increase the thickening time of the slurry at high temperatures. Only 0.4 weight percent CMHEC based on the dry cement is required to permit the pumping of the full 18,000-ft schedule (API-RP 10B) in which a maximum circulating temperature of 300 F (equivalent to a static hole temperature of about 350 F) and a maximum pressure of 18,800 psi are developed. With 1.5 weight percent CMHEC the slurry remains fluid for over 3½ hr under the same severe test conditions.

Fig. 1 illustrates the effect of CMHEC concentration on slurry thick-

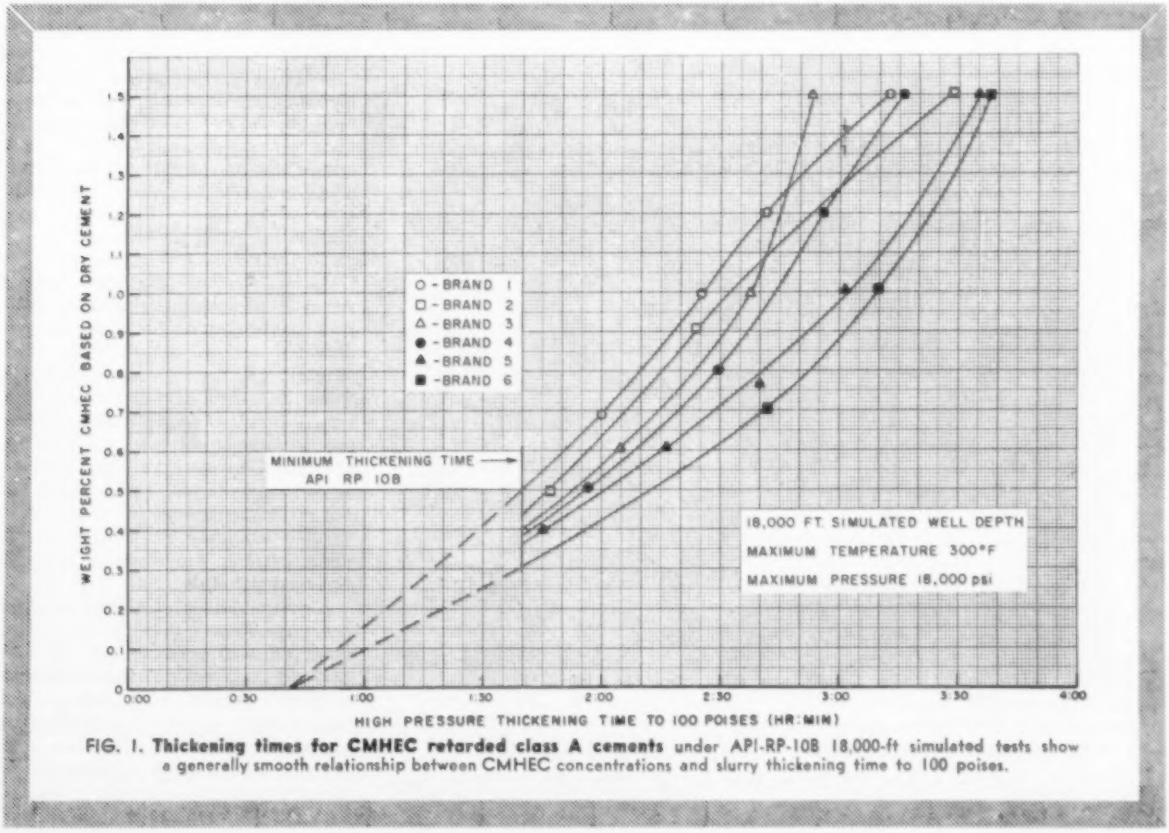

FIG. 1. **Thickening times for CMHEC retarded class A cements** under API-RP-10B 18,000-ft simulated tests show a generally smooth relationship between CMHEC concentrations and slurry thickening time to 100 poises.

ening time under conditions of the 18,000-ft test schedule for several different brands of common (Class A portland cements. It is shown that for any given cement there is generally a smooth relationship between CMHEC concentration and slurry thickening time to 100 poises. Although there is considerable variation in the thickening properties of the different brands of cement, it should be noted that all cements tested easily pumped the full 18,000-ft schedule with the addition of relatively small amounts of CMHEC (no more than 0.5 weight percent).

Set Strengths

CMHEC is such a strong set retarder that it materially reduces early set strengths of portland cement, particularly at low temperatures. A concentration of only 0.3 weight percent of the high viscosity grade is sufficient to prevent a 24-hr set in samples cured at 180 F. However, at higher temperatures the large cellulose molecule is sufficiently degraded to permit the setting process. Some strength data for portland cement containing varying amounts of CMHEC are included in Table 1. It is seen that good 24-hr strengths are obtained at temperatures higher than 260 F even for relatively large concentrations of CMHEC.

The addition of a fine-grind (95 percent passing 200 mesh) silica sand to a CMHEC-retarded cement significantly increases 24-hr strength without adverse effects on the thickening time. This is shown in Table 2 for an unweighted and a weighted system. Note that compressive strengths in excess of 6000 psi can be obtained with a cement containing a considerable amount of barite.

Slurry Fluid Properties

The addition of small amounts of CMHEC to portland cement slurries has some effect on the fluid properties. With concentrations of the high-viscosity grades above 0.5 weight percent, Class A portland cement slurries become viscous, especially when the water content is low. However, slurry viscosity decreases with increasing temperature and all CMHEC-retarded slurries are highly fluid at normal borehole temperatures.

Low viscosity grades of CMHEC produce much lower slurry viscosity during initial mixing. In Fig. 2, a plot is given of viscosity versus thickening time for two high-pressure consistometer runs on Class A cement slurries containing high and low viscosity grades of CMHEC. It is seen that the slurry containing the less viscous type has a much lower initial viscosity but the overall time-thickening properties of the two grades are approximately the same. Consistometer run No. 1 also illustrates how rapidly the viscosity of slurries containing high-viscosity CMHEC decreases with increasing slurry temperature. Also given in Fig. 2 is a similar high-pressure consistometer test of a commercial oil well cement. A comparison of these viscosity-thickening time relationships illustrates the relative effectiveness of CMHEC in maintaining low slurry viscosities over extended periods at high temperatures and pressures.

Bergman,[4] et al, have shown that CMHEC common portland cement slurries also have good filter loss properties over a wide temperature range. With 0.5 weight percent CMHEC in the slurry fluid, water-loss in the range of 10 to 20 cc (API Recommended Practice 29) can be obtained. As might be predicted, additional amounts of CMHEC will further decrease filter loss. For a fixed concentration of CMHEC, higher temperatures produce higher filtration rates. For temperatures above 120 F, CMHEC concentrations below 0.5 weight percent have little effect on the filtration properties of most slurries.

TABLE 2. Effect of Silica Flour on the Compressive Strength of CMHEC-Retarded Cements.

Cement	Slurry Composition Weight Percent* CMHEC	Weight Percent* Silica Flour**	Slurry Density lb/gal	Compressive Strength, psi (curing pressure 5000 psi) Curing temperature F	Curing Time 1 day	3 days	14 days
Class A	1.0	0	14.6	300	2985	2375	500
	1.0	22.5	14.6	300	3250	4958	6800
Class E (oil well)	0.5	0	17.3	320	1165	1033	—
plus barite	0.5***	22.5	17.3	320	4642	7415	—
	0.5	35.0	17.3	320	5642	6550	—
	0.5	50.0	17.3	320	5433	5833	—

*Weight percent based on dry cement.
**Silica flour 95 percent passing 200 mesh.
***API 18,000-ft casing cementing schedule thickening time: 2 hr 11 min.

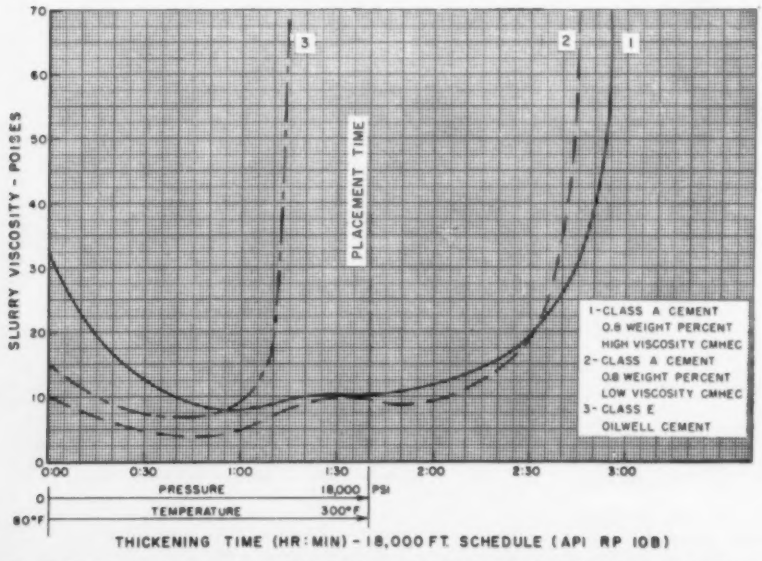

FIG. 2. **Performance tests under 18,000-ft simulated conditions** (API-RP-10B) **for three cements. These curves indicate the effectiveness of CMHEC in maintaining low slurry viscosities over extended periods at high temperatures and pressures.**

Cement Comparisons

To illustrate the effectiveness of CMHEC on thickening time and set strength of portland cement, high-pressure thickening time and strength data for several commercially available oil well cements are included in Table 1. A direct comparison of these data shows that much longer thickening times can be obtained with CMHEC—Class A mixes than with other retarded cements and that control can be easily maintained by the use of varying amounts of CMHEC even under extreme conditions of temperature and pressure.

Set strengths of CMHEC-retarded cements compare very favorably with other oil well cements. At low temperatures, strengths are sensitive to CMHEC concentration, but at high temperatures very good early strengths are obtained particularly when silica flour is added. Only a minimum of high-temperature strength data are available for most commercial oil well

TABLE 3. Bore Hole and Cementing Data from Field Applications of CMHEC Cements.

Operation Number	Cementing Operation	Placement Depth, ft	Static Well Temp, F	Slurry Parameters: bbl	lb/gal	Weight percent CMHEC	Final Placement Pressure (psi)	Placement Time (hr:min)	Consistometer Thickening* Time (hr:min)	24 hr Comp. Strength (psi) at Well Temp.
1	Prod. casing	10,867	210	300	14.7	0.20	1200	1:10	6:00†	3200
2	Prod. casing	15,500	308	125	14.7	1.00	1700	2:28	5:00†	1300
3	Plug back	13,929	385	5	16.0	0.90	1250	0:36	2:10	2500
4	Squeeze	13,720-13,779	380	10	15.5	0.90	5200	1:05	1:44	2450
5	Bradenhead squeeze	21,523-21,622	330	96	17.6	0.75	5000 tubing 3000 casing	4:38	3:35	1360
6	Liner	16,350	325	50	17.0	0.51	3000	0:55	4:00†	—

†Slurry still fluid at indicated time.
*Consistometer maximum temperature and pressure same as indicated borehole values.

cements. However, in the temperature range of 260 to 290 F it is seen (Table 1) that CMHEC — Class A cements gives strengths comparable to commercial oil well cements.

FIELD APPLICATIONS

CMHEC-portland cement mixes have been used successfully in a variety of oil well cementing operations. A summary of bore hole and cementing data for several field applications is given in Table 3. All field applications were made with relatively high viscosity grades of CMHEC.

First Field Test

The well selected for the first application of CMHEC as a retarder had a bottom-hole temperature of 210 F. Completion of the well called for cementing a 7-in. production casing at 10,867 ft with a retarded cement that could be placed in a single stage operation. Class A portland cement was mixed dry with 0.2 weight percent CMHEC in conventional bulk blending equipment. Approximately 300 bbl of 14.7 lb per gal slurry were placed behind the casing in 1 hr and 10 min with a maximum surface pressure of 1200 psi. Laboratory tests made in a high-pressure consistometer indicate that this particular slurry mix had a pumping time of over 6 hr under the given well conditions. The set strength after 24 hr was 3200 psi.

This initial field trial proceeded satisfactorily; a fill of over 90 percent was obtained behind the casing. The test showed that standard bulk mixing equipment can be used to prepare homogeneous dry mixes and that conventional slurry preparation and pumping equipment can be used to place this type of cement.

Production Casing and Liners

The first applications of CMHEC-retarded cement under severe conditions of temperature and pressure were in the cementing of production casing and liners in deep wildcats (operations 2, 6; Table 3).

A 7⅝-in. extra heavy casing was cemented successfully at a depth of 15,500 ft with 125 bbl of slurry having an average density of 14.7 lb per gal. Five hundred sacks of portland (Class A) cement containing 1.0 weight percent CMHEC were used in the preparation of the slurry. Because of the relatively high concentration of high viscosity CMHEC, the initial slurry was viscous and a pump pressure of 2500 psi was required to start the slurry down the casing. However, as the slurry temperature increased with deeper displacement the viscosity decreased and the surface pump pressure at final placement had decreased to a value of 1700 psi. A total time of 2 hr and 28 min was required to prepare and place the total slurry volume behind the casing. Laboratory tests made on samples of cement used in this operation indicated that over 5 hr of pumping time were available for the given well conditions (308 F and 15,000 psi). The set strength after 24 hr was 1300 psi.

A CMHEC cement was easily placed behind a deep liner (operation 6; Table 3). In this wildcat, a 5-in. liner was successfully placed to a depth of 16,350 ft where the estimated bottom-hole temperature was 325 F. A weighted slurry with a pumping time of 4 hr was desired for the cementing operation.

Fifty barrels of 17.0-lb per gal slurry were prepared, using regular barite and approximately 0.5 weight percent CMHEC based on total solids. The slurry was pumped behind the liner in a total of 55 min. Laboratory tests made on samples of the cement used in the field completion indicated that the slurry had a pumping time of over 4 hr under the given well conditions. The top of the liner was successfully pressure-tested approximately 24 hr after final placement.

Plug-Back and Squeeze Operations

CMHEC-retarded cements were used in both plug-back and squeeze operations in a problem well in West Texas. The unusual temperature gradient in this area gave a borehole temperature in the range of 380 to 390 F at the 15,000-ft level. Because of these extreme temperatures no attempts were made to place regular oil well cement through tubing. After several unsuccessful attempts to spot a plug at 13,929 ft with dump bailers, a CMHEC-retarded slurry was prepared using oil well cement containing 0.9 weight percent CMHEC. A plug of 5 bbl of 16.0 lb per gal slurry was easily spotted through tubing. At this depth (13,929 ft) the measured temperature was 355 F. Only 36 min were required for the operation, which was well below the 2 hr and 10 min pumping time that was available for this particular cement mix according to laboratory tests.

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Freeman D. Patchen is a technician specialist at the Field Research Laboratory of the Magnolia Petroleum Company in Dallas, Texas. A native of Texas, he completed two years of study at Blackburn College in 1936. After five years of non-technical employment he served 4½ years as communication chief for a field artillery battalion in the Pacific Theater. After discharge in late 1945, he was employed for six years in the laboratory of Lone Star Cement Corporation. Since joining Magnolia in 1951, Freeman has been engaged in experimental work in cement research both in laboratory and field application. He is currently enrolled as a special student with senior status at Southern Methodist University seeking a BS degree in chemistry.

A similar cement mixture was used to squeeze off perforations between 13,720 and 13,779 ft. A total of 10 bbl of 15.5 lb per gal slurry was used in this operation, the slurry being mixed and pumped opposite the perforations in approximately 35 min. A pressure of 3300 psi was required to break down the formation and approximately 5 bbl of slurry were pumped into the formation at a surface pressure of 1500 psi. A total of 6 hesitation squeezes were used in developing the final squeeze pressure of 5200 psi, which was obtained 1 hr and 5 min after initial mixing. After the final squeeze, the remaining slurry was easily reversed out of the tubing. Laboratory tests made on samples of cement used in both cementing jobs on this well showed excellent pumping characteristics and 24-hr set strengths of about 2500 psi.

A CMHEC cement was also used to seal off perforations between 21,523 and 21,622 ft in another deep wildcat[5] (operation 5). CMHEC was employed because of previous difficulties with other retarders and specially prepared cements. Although this cementing operation was at a greater depth than previous applications, the static borehole temperature was not particularly high (326 F). The dry blend of the first operation consisted of 260 sacks of oil well cement, 196 sacks of a coarse grind of barite and 260 lb of CMHEC (0.8 weight percent based on total solids). The barite was used to provide a 17.5-lb per gal slurry. The resulting slurry had a high viscosity and was picked up by the pumps with difficulty. Measured tub densities averaged 17.4 lb per gal. However, the slurry was air cut and the calculated density was 17.9 lb per gal. No appreciable squeeze pressures were developed in 3 hr and 5 min, and because of difficulties with the cementing tool, operations were suspended while the slurry was still quite fluid. The top of the cement was found at 21,536 ft leaving 13 ft of perforations exposed.

On the second attempt, no packer was used and a bradenhead hesitation squeeze technique was successfully employed. The dry blend of this operation was 300 sacks of oil well cement, 225 sacks of coarse grind barite and 380 lb (0.75 weight percent) of CMHEC. In order to reduce the high initial viscosity to permit easier handling, warm water (140 F) was used in preparation of the slurry. This procedure increased the initial slurry temperature and resulted in a reduction in slurry viscosity, although it was still high. Surface pump pressures in the range of 5000 to 7000 psi were used in mixing and placing a total of 96 bbl in the tubing. Difficulties with the pumping equipment were encountered during the initial displacement of the slurry with mud and at one time it was necessary to use auxiliary pumps while repairs were made on the primary unit.

A total of 1 hr and 43 min was required to pump the first part of the slurry to the perforations between 21,523 and 21,536 ft. At this point the blowout preventers were closed and the slurry was pumped into the formation. At this time, a surface pressure of 4000 psi was required to displace the slurry into the formation at a rate of 2½ bbl per min. When 20 bbl of slurry remained in the tubing, the displacement rate was reduced to a value of ¼ bbl per min. Surface pressure of 3000 psi on the tubing and 1800 psi on the casing were associated with this reduced flow rate.

After displacing 7 more bbl, and 3 hr and 52 min after initial mixing, the first pressure buildup was noted. Six hesitation squeezes were then carried out with 5 to 10 min intervals between squeezes. On the final squeeze, pressures of 5000 psi in the tubing and 3000 psi in the casing were obtained. A total of 4 hr and 38 min elapsed from the initial mixing of the slurry to the completion of the final squeeze.

This time is considerably more than the laboratory evaluated thickening time limit of 3 hr and 35 min for this particular cement under the given well conditions. However, a large portion of the total operating time was utilized in initial mixing and displacement of slurry down the tubing. During this period, temperatures were too low to cause appreciable decomposition of the CMHEC retarder. Actually, the 3 hr required for the pumping of the slurry into the formation and for the hesitation squeeze compares very favorably with the laboratory evaluated thickening time.

The tubing was easily removed from the bore hole after the final hesitation squeeze and a 24-hr test of the zone showed a successful shut-off. Measured set strength for this cement was 1360 psi in 24 hr.

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Accelerated activity in recent years in offshore drilling and development has not been confined solely to the U.S. The oil-rich areas within Lake Maracaibo have long been the site of offshore activity. According to Compania Shell de Venezuela Ltd., circumstances are completely different in the lake area from those governing U.S. offshore operations. Average weather conditions are not severe, and wave heights of more than 6 ft are exceptional. Distances from the shore to operating areas at present are not more than 25 miles.

Depth of the lake, down to the top of the soft mud layer varies between 60 and 120 ft, while hard layers are found at depths between 160 to 180 ft below the lake bottom. The latter depth determines the length of piles in the drilling foundation.

Wells are drilled from small steel platforms which support the derrick, drawworks and engines. A drilling tender with slush pumps, pipe racks, generating equipment, and allied equipment as well as helicopter deck, is moored near this platform.

Average depth of wells is from 6000 to 8000 ft, and a number of exploratory wells have been drilled below 10,000 ft.

Production is received by platform-supported tank batteries where gas is separated and the oil is treated if necessary. The crude is then pumped ashore through submarine trunk lines. Shell has 14 such tank batteries, and four main trunk lines to carry oil ashore. Two go to the western shore of the lake and two to the eastern shore.

Typical offshore tank battery of Compania Shell de Venezuela in Lake Maracaibo. Shell operates 14 such batteries.

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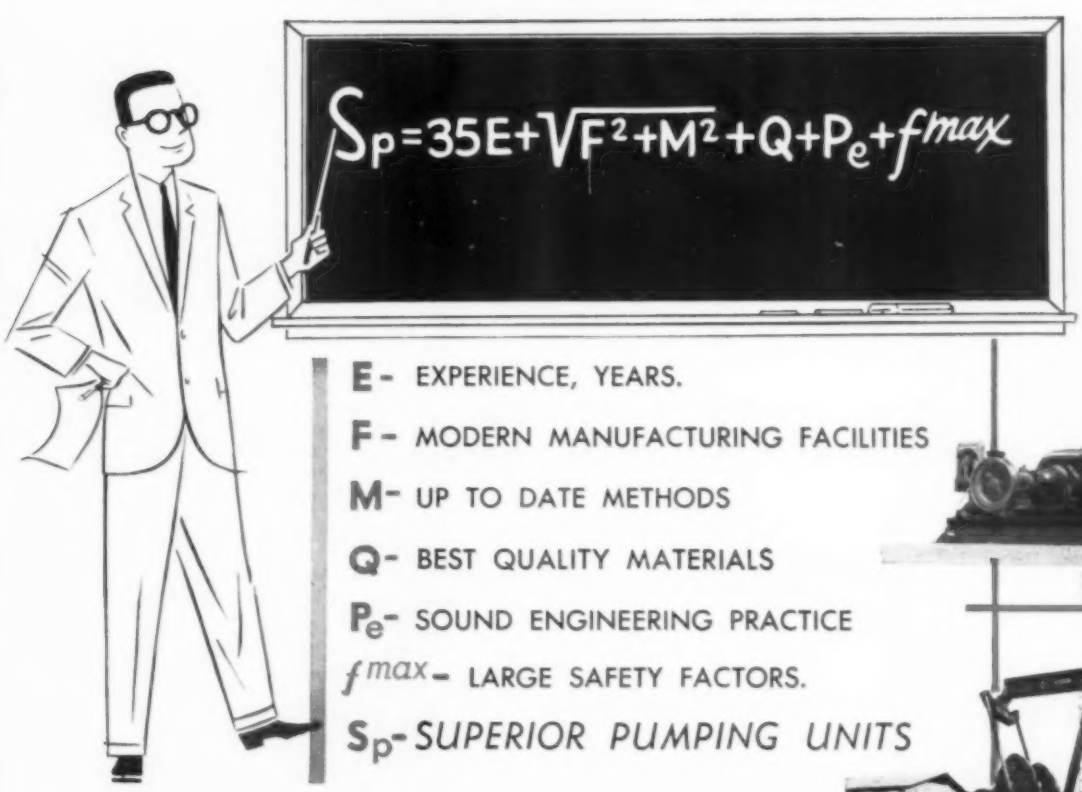

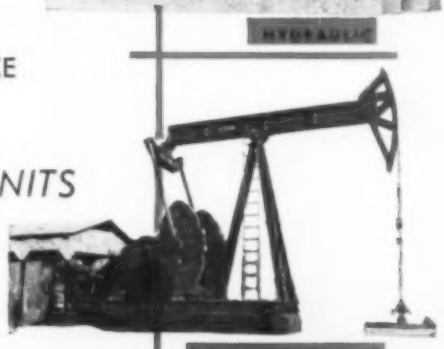

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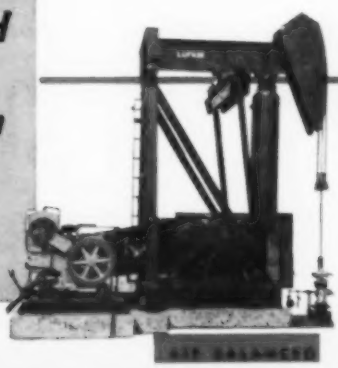

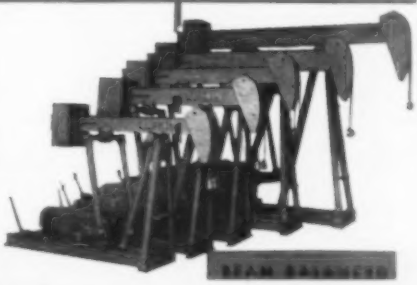

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**The unit purchased by A. B. Vaught, Midland, Texas, is a twin-engine, single-drum L-350 with rotary drive and a 15" double rotor hydromatic brake package, in combination with Cardwell's new 96' free-standing mast.*

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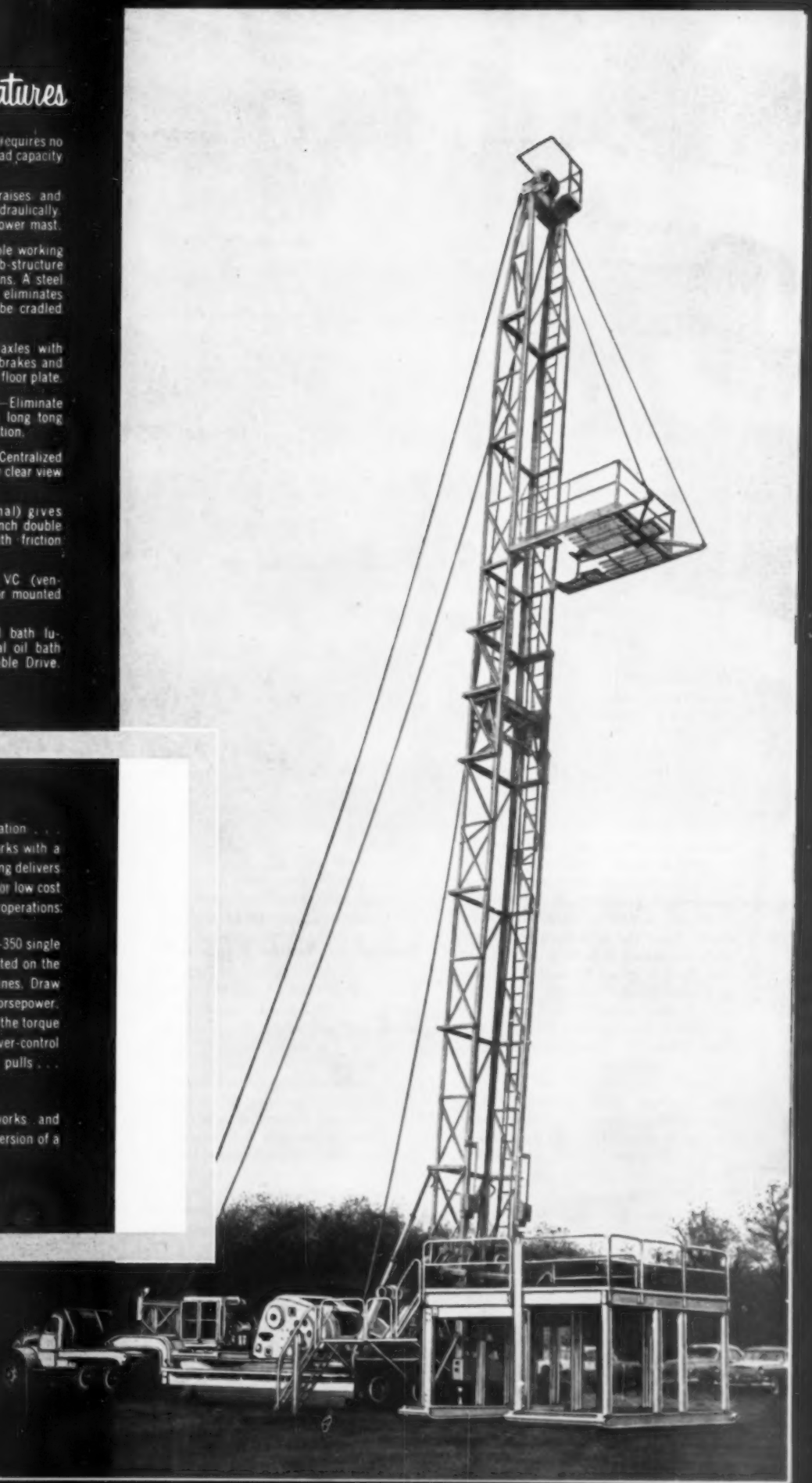

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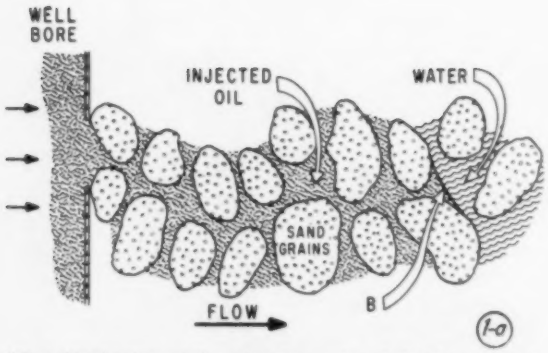

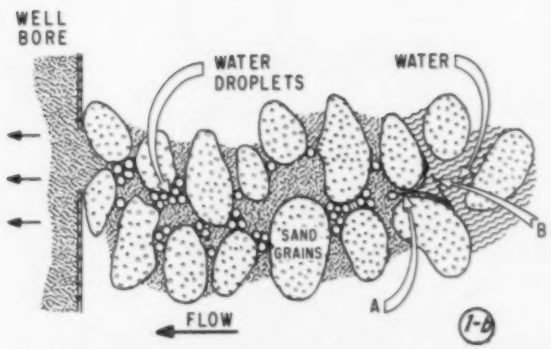

FIG. 1. **Mechanism of the selective water shut-off process.** 1-a — Surfactant in oil is injected into formation, making it oil-wet and displacing water to boundary "B." 1-b — Reversing flow causes minute water droplets (water-in-oil emulsion) to form at first pore constriction "A," followed by blocking subsequent constrictions with droplets or groups of droplets.

In Oil Well Remedial Work . . .

Surfactant Treatment Selectively Seals Off Water Entry

W. E. Brown

Major Research Laboratory
The Western Company
Dallas, Texas

Unusual additive forms a water-in-oil emulsion with formation water to block flow . . . but does not effect oil-producing zones

THE INJECTION of an unusual surfactant composition mixed in crude oil, refined oil or other suitable petroleum liquid has proved to be effective in selectively shutting off water entry into the well bore of a producing oil well. Upon contact with formation water, a water-in-oil emulsion is formed that serves as a barrier to further water entry. Since the treatment reacts only with formation waters, it does not affect the flow of oil from other sections in the perforated or producing interval. In this respect, the process, developed by the Research Department of The Western Company, Midland, Texas, is selective.

During injection of this treatment, the reservoir rock becomes oil-wet, but no other change is noted. When injection is completed and the fluid begins to migrate toward the well, a water-in-oil emulsion is formed wherever the water attempts to displace the treating fluid. This type of emulsion is formed because water becomes the internal phase in the resulting oil-wet pores. And, at each pore constriction, the water is broken into spherical droplets by the surfactant in the treated oil. These droplets act as ball-check-valves at each subsequent pore constriction to effectively block further water entry. Principle is illustrated in Fig. 1-a and b.

Excessive water production is costly not only because of pumping, separation and disposal difficulties, but also because of reduced oil production. The viscosity ratio of water to oil generally is in favor of water migration, and once water enters a well, it normally increases in volume very rapidly, usually at the expense of oil production.

Sources of Water Production

Among the sources of produced water are an active water drive, water stringers, a channeled primary cement job as well as casing leaks. Water drive reservoirs are subject to water coning and fingering. Water coning occurs when water migrates from a lower portion of the producing zone up into the oil producing section of a well in response to the pressure drop in the borehole resulting from withdrawal of fluid (Fig. 2).

Stability of the cone is due to a combination of a dynamic effect and capillary forces wherein the pressure gradient associated with the flow of fluid into the borehole plus capillary action in the pores of the water-wet reservoir rock are able to balance the hydrostatic head of the resulting elevation in the water-oil contact.

The importance of capillary forces has been pointed out by Michaels.[1] The capillary effect can cause a water cone to rise to a much higher level than would be expected from simple hydrodynamic calculations, e. g., a capillary pressure of 0.6 atm can produce a water cone rising 60 ft through oil with a specific gravity of 0.7. Obviously then, a small localized region of lower pressure around a well is sufficient to produce a sizable water cone. As a coning situation develops, the water progressively encroaches upward beneath the well before entering the borehole. As water reaches the bottom of the well, it rises rapidly in the formation adjacent to the borehole. The flow area available for oil entry is reduced until production from the well is largely water, even though much oil remains in the reservoir. Water fingering is a similar situation involving lateral instead of vertical water movement as indicated in Fig. 3-a and 3-b.

A related condition exists when an oil well has been fractured into a water zone below the oil-saturated interval. Here, the sand filled fracture provides a high permeability channel connecting the borehole with the water zone (Fig. 4). Even though the fracture may have penetrated a considerable thickness of oil saturated sand before encountering water, the production is mostly, if not entirely, water.

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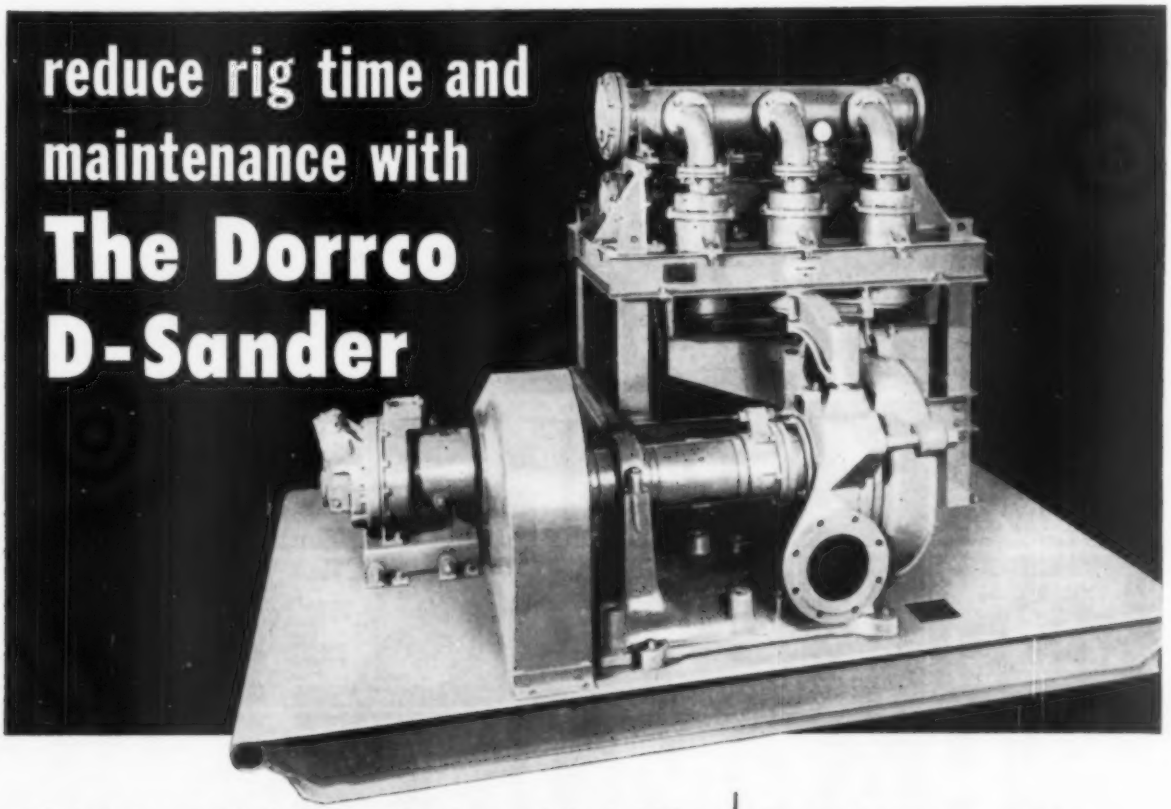

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	57 hrs. at $62.50	**$3,562.50**

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Mud pump parts	1,400.00
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For more information on the Dorrco D-Sander contact our U. S. Sales Representative, Salt Water Control Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

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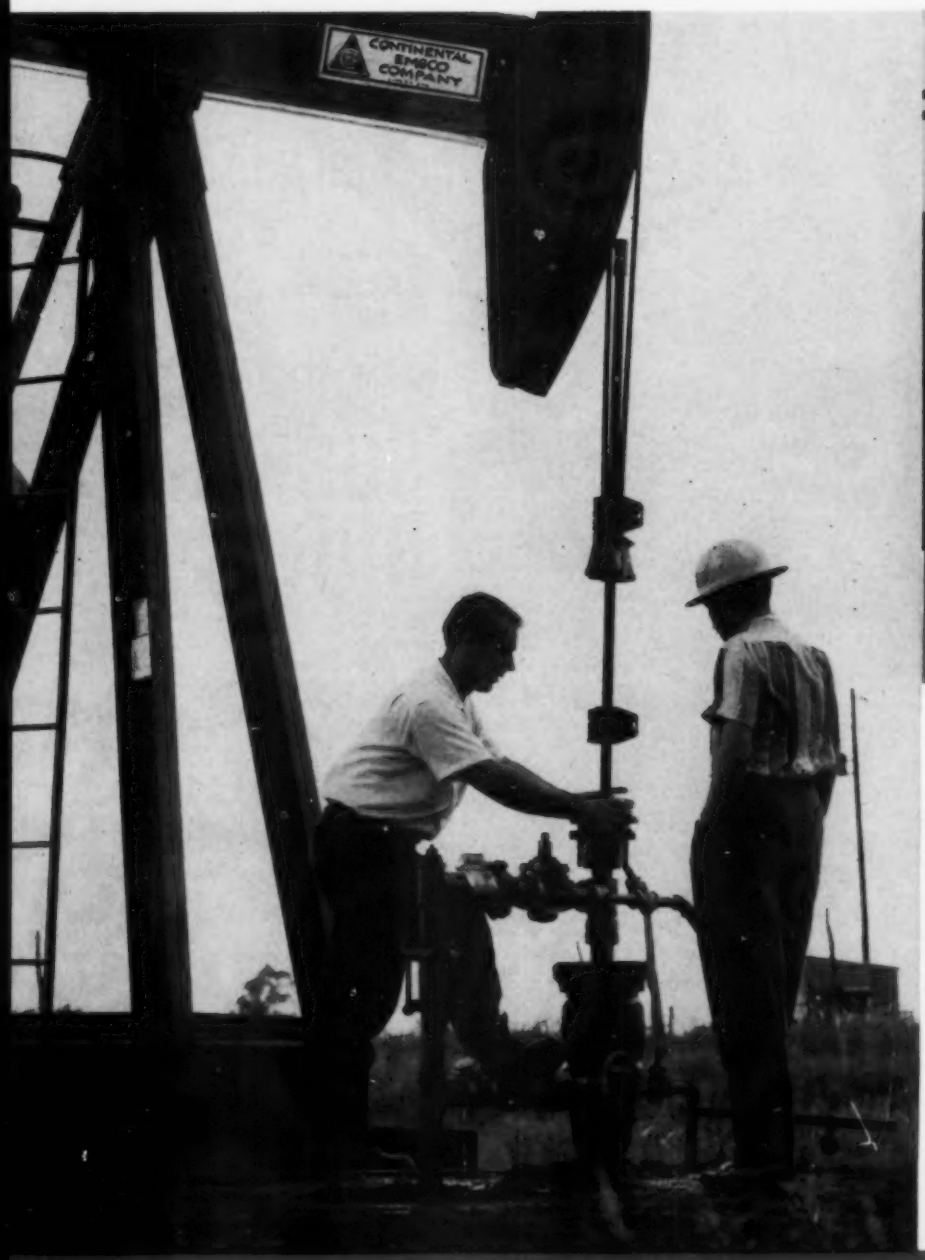

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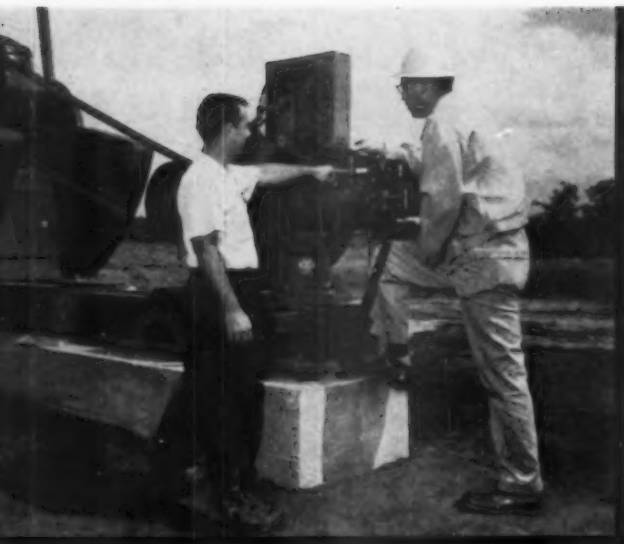

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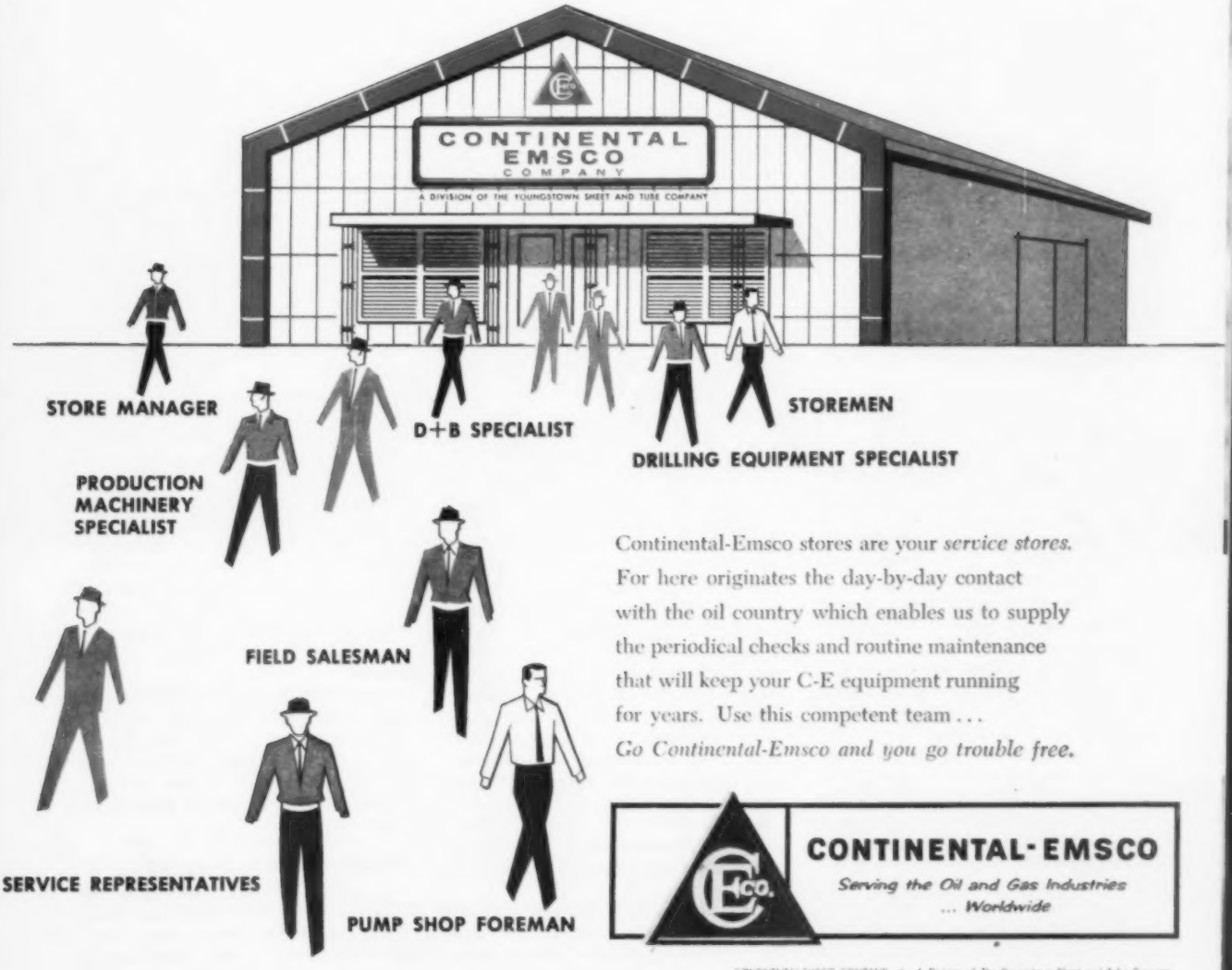

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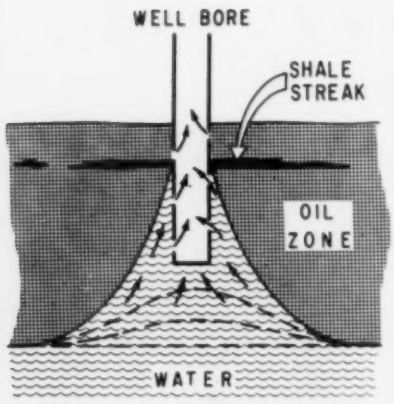


FIG. 2. **Water coning into well bore** of an oil producing well, showing stages of encroachment (dotted lines) and effect of shale streak.

Thin, high permeability streaks in a producing formation often conduct water to the borehole far in advance of the general water-oil contact. Water from these streaks can seriously reduce production from the remaining oil saturated zone, and at best, a large amount of water must be produced to deplete the remaining oil (Fig. 5).

The presence of shale breaks or other stratified impermeable or low permeability streaks in sedimentary reservoir rocks creates a similar situation where the barrier prevents a more permeable stratum from acting as a drainage channel for the oil in adjacent zones. This causes the permeable zones to become conduits for water entry into the producing well. Many secondary-recovery waterflood operations have experienced premature water breakthrough from this cause.

Water production also arises from channels in cement jobs, casing leaks or other direct communications with aquifers (Fig. 6). In the instances of water entry cited above there exists a real possibility of "drowning out" the oil production and, in any event, the numerous disadvantages associated with water production must be faced.

Methods of Water Shut Off

A myriad of methods for shutting off water production has been proposed, many of them elaborate and often unworkable for practical reasons under actual well conditions. Most of these remedies involve a solid plug in the well bore or a solid block entirely filling the reservoir pores adjacent to the well bore. Those involving a pore plugging mechanism usually require a reaction with water in the pores to produce the block. Not even the materials requiring reaction with water to form a plug can be considered selective since they do not differentiate between the water in a barren zone and the connate water in a section with continuous oil saturation. Thus, such methods can and often do block oil productive zones.

The use of a solid material to plug off the bottom of the borehole in a water coning situation has been temporarily successful in some wells. The presence of local shale breaks, however, is probably necessary to derive benefit from such plugs.[2] It is obvious, however, that since the cone passes through a considerable zone of oil saturation the continued use of bottom plugs to shut off a water cone will completely block off the productive interval long before the oil has been depleted. "Oil saturated" producing formations always contain connate water of which little if any is produced and, since this water often occupies more than 20 percent of the pore space in the rock, it is understandable why severe blocking occurs in oil zones treated with materials which react with water to create a solid plug.

In order to avoid plugging off the oil zone, various schemes have been used including packers, bridge plugs, temporary blocking agents, etc. One method involves setting a packer at the oil-water interface and pumping the blocking agent under the packer into the water zone while injecting oil down the annulus into the oil zone to prevent the block from migrating up into the oil zone.

A similar process uses two solutions which react upon contact to form a block at their interface. Straddle packers have been used in attempts to inject a thin layer of blocking agent at the oil-water contact. In the latter two cases the bottom of the hole must be plugged later to the level of the oil-water contact after the block has been placed.

All of these methods presuppose that an actual oil-water contact exists, its location is accurately known, and a packing device can effectively isolate one zone from the other. In actual oilfield operations the entry points of the water are often unknown and isolation of one zone from another with a packer is very difficult to accomplish, especially in open-hole sections, continuously perforated sections, or sections with slotted or perforated liners.

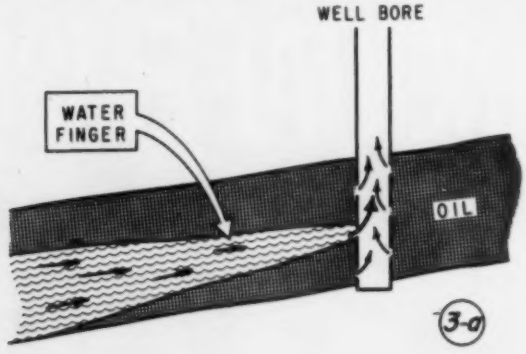
Another method utilizes a cement filled horizontal fracture at the oil-water interface. The extreme difficulty of controlling the location and plane of such a fracture is known; however, a recent development may make this process operable under favorable circumstances.[3]

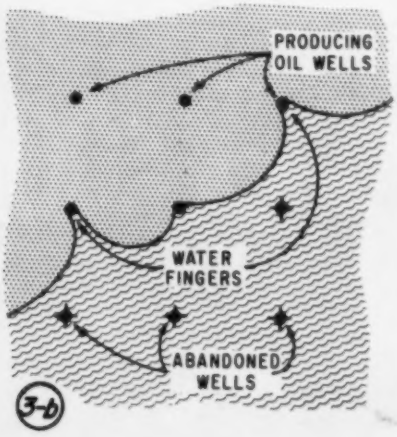
Selectively needed. The above procedures serve to demonstrate that what is required is a truly selective process which will block water without blocking oil and does not involve isolation or even knowledge of the location of water entry.

Selective Water Shut Off

A process for the selective shut off of water has been developed for use in reservoirs having intergranular, intercrystalline, and small tight-fracture types of porosity. This method was developed from basic theory which indi-

FIG. 3. **Water fingering** occurs in high permeability streaks in oil zones (3-a) or through a lateral equivalent of vertical water coning (3-b).





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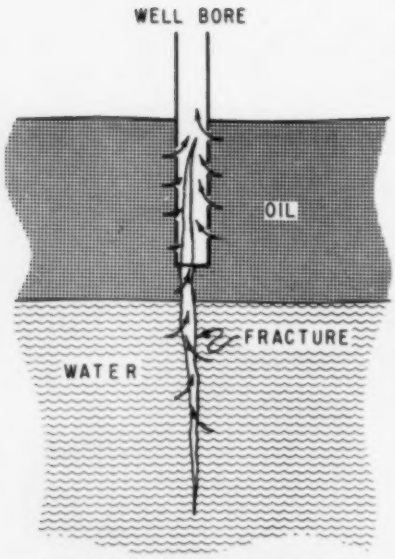


FIG. 4. **Fracturing into water zone** is another cause of high water-oil ratios.

cated that water migration could be effectively controlled utilizing only the effects of interfacial tension and wettability of the reservoir rock. After a number of years of intensive research and field testing a practical process was developed. More than 300 closely controlled individual laboratory flow studies with limestone and sand cores were made. Over 25 field tests were used to evaluate the process, determine optimum operating procedures and the limits of applicability.

Basic idea. The mechanism by which water migration is prevented is simple and positive. By converting the pore walls from a water-wet to an oil-wet state, any water which enters a pore necessarily becomes the internal phase in a funicular distribution as shown in Fig. 7. As this water reaches and passes through a pore constriction, it will be broken into small spherical droplets which upon further migration will seal subsequent pore constrictions. The resistance to deformation of these spherical water droplets causes them to have this ball-check-valve action. This is the basic idea underlying the Selective Water-Seal Process. The particular process described above is referred to as Type I.

The force necessary to displace a droplet lodged in a pore constriction can be calculated.[4,5] The pressure required to force a single droplet with a diameter of 0.10 mm through a pore constriction of 0.04 mm diameter, assuming an interfacial tension of 20 dynes per cm, is 12,000 dynes per cm^2. To generate this differential by parallel flow of the surrounding oil requires a gradient of about 530 psi per ft. Since numerous pore constrictions are blocked in series, this effect is additive and thus very high gradients can be established without moving the water droplets. In radial flow patterns, pressure gradients of this magnitude do not exist in the reservoir even in the immediate vicinity of the well bore.

Surfactant used. The interfacial tension between water and oil causes the droplets to assume a spherical form (minimum surface) and since energy must be expended to increase the surface area of the droplets, they resist deformation. This resistance, of course, is directly proportional to the interfacial tension and therefore the highest possible interfacial tension would be best. However, it is also true that droplets with a high interfacial tension are not only difficult to form, but are also inherently unstable and tend to coalesce spontaneously. What is required is a surfactant composition which will cause all types of reservoir rock to become oil wet and which will aid in the formation of droplets and stabilize them without lowering the interfacial tension to the point where the droplets no longer resist deformation. A unique surfactant with these properties was developed and has been tested thoroughly in the laboratory and in the field.

Experiments have shown that when a solution of this surfactant in oil enters a water saturated sand the water is displaced with a piston-like action. There is no emulsion formation, although occasionally small slugs of water are by-passed. Apparently, the injection could be carried on indefinitely. In contrast, however, immediately upon reversal of flow wherever water attempts to penetrate the zone occupied by the treated oil, a thick emulsion forms and the flow is blocked. This happens because during injection the treating solution is invading water-wet pores. Upon reversal of flow, water must become the internal phase. *Since the surfactant can produce only a water-in-oil emulsion, no droplets form during injection although they form readily and immediately upon reversal of flow* (Fig. 7).

In zones where a continuous oil phase is present, the injected fluid merely displaces the oil from the pores and, since a slow rate of injection is used, connate water which is displaced by the treated oil is able to flow radially along the matrix without altering the continuous state of the oil phase. Occasionally it has been noted that a small slug of connate water is bypassed in what appears to be a stagnant area and it remains immobile despite continued injection of the treating solution.

Upon reversal of flow, the connate water simply flushes the injected fluid out of the formation into the well bore and oil production can proceed without interruption. Since crude oil is completely miscible with the treatment, no block can form in any zone of continuous oil saturation. Isolated slugs of water formed as outlined

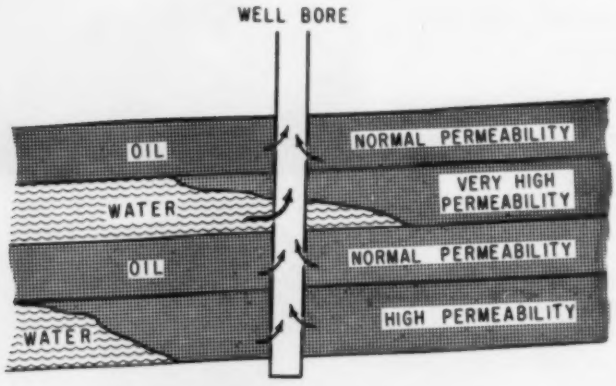


FIG. 5. **Premature water breakthrough** via high permeability streaks in an oil zone.

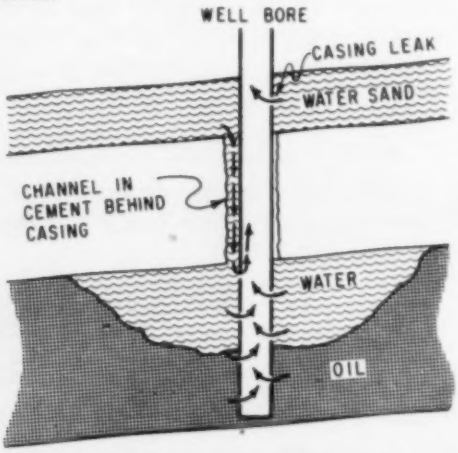
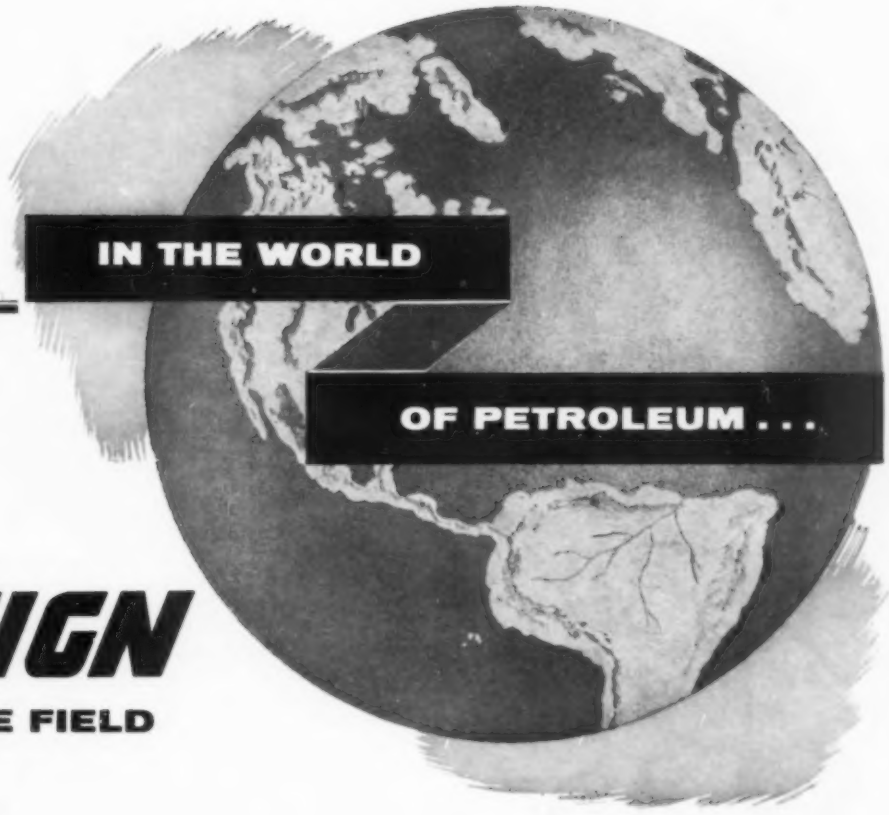


FIG. 6. **Channel in cement and casing leaks** result in water production with decreased oil flow.

IN THE WORLD



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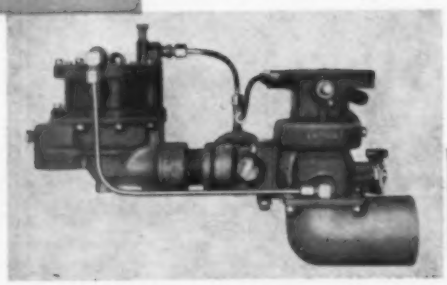

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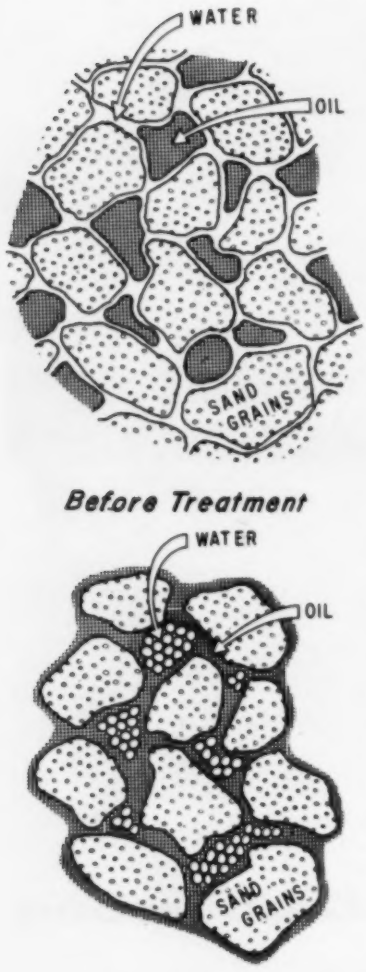

FIG. 7. **Fluid distribution** in reservoir rock before and after selective water shut-off treatment, showing change in water phase from pendular ring to funicular distribution.

above are by-passed by the return flow and have little if any effect on the return flow of oil since they seem to form only in regions of stagnation.

Solvents used. Any suitable solvent miscible with crude oil, immiscible with water and having the necessary interfacial tension relationship will be useful in this process. Lease crude has been used because of its availability and known compatibility with the formation oil. Diesel oil has been found most suitable for field use.

Treating the Well

In actual operations, a solution of this surfactant in pipeline quality crude oil is pumped into the well at a slow rate. Usually, the treatment is carried out with a packer set as close as possible to the productive interval. This serves to exclude the water standing in the casing from being pumped into the oil bearing zone ahead of the treatment. A packer is not required for wells in which the fluid level can be lowered to the interval to be treated. In order to ensure that the oil saturated zone extends into the borehole at the time of the treatment, the well is produced at a high rate after the packer has been set until immediately prior to treatment. This flushes water out of the oil productive zone near the borehole. It has been demonstrated that with a very slow injection rate, the few barrels of water in the tubing go back into the water zone with little if any invasion of the oil zone. Care is taken not to approach the formation breakdown pressure or, in the case of wells which have been fractured, the treating pressure. When the required volume of treated oil has been pumped away, it is further displaced into the formation to the desired distance from the well bore with a smaller quantity of oil as overflush.

Reversing flow. After the treatment, a volume approximately equal to the overflush is withdrawn from the formation, usually by swabbing. This causes fluids to migrate toward the borehole and wherever water tries to displace the treating solution a block forms. In any zone having continuous oil saturation, no droplets can form and the treatment is flushed into the well by the native crude oil. Thus, oil is selectively produced while water is selectively blocked (Fig. 8). The well can be returned to production immediately.

Because the mechanism of a block of this type requires pore constrictions, it obviously will not be effective in large open fractures, vugs, solution channels, etc., although it is very effective in intergranular or intercrystalline porosity or in small tight fractures. Wherever there is a flow channel of sufficient size for the droplets to pass without distortion, no block will be noted. It is possible that graded sand injected with the treating solution or otherwise packed into fractures, vugs, etc., could be used to create intergranular porosity. This is currently under investigation.

Further development. In a further refinement of this process, additional ingredients are included in the treating solution which have the effect of solidifying the water droplets without otherwise changing the properties of the solution. This greatly increases the pressure needed to force a droplet through a pore constriction. In effect, this produces fine grains of solids within the pores and further enhances the strength of the block. This treatment is called Type II of the process. Laboratory and field tests indicate that this process is particularly applicable in high permeability formations.

Limitations of Process

Theoretically, the Selective Water-Seal Process should work in all wells where water is produced from intergranular, intercrystalline, etc., types of porosity and where oil is present as a continuous phase. However, if water and oil are produced either concurrently or alternately from the same pores, this process is not applicable. Such situations are encountered where connate water is produced with the oil and where a watered-out sand is producing slugs of oil intermittently through the flushing action of large volumes of water.

There are certain types of wells in which this water shutoff treatment may not be operable.

Vuggy formations. Wells producing from formations containing vugs and solution channels cannot be success-

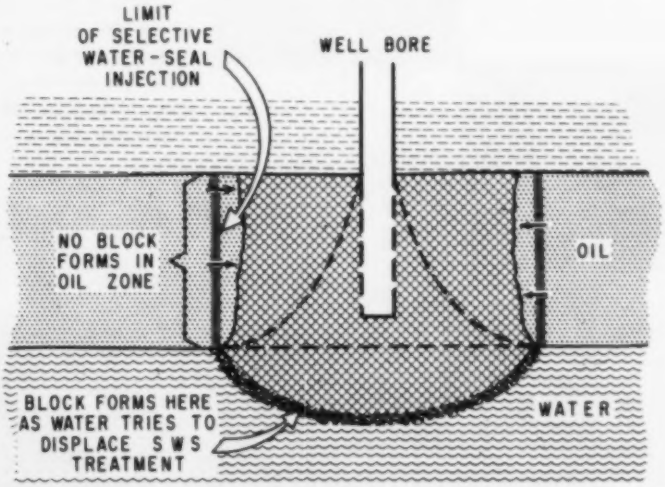
LIMIT OF SELECTIVE WATER-SEAL INJECTION
WELL BORE
NO BLOCK FORMS IN OIL ZONE
OIL
BLOCK FORMS HERE AS WATER TRIES TO DISPLACE SWS TREATMENT
WATER

FIG. 8. **Selective water sealing action** in typical water coning condition. After treatment to depress cone, water migration to well bore is blocked as indicated, while flow of oil to well is unhampered since treatment is miscible with oil.

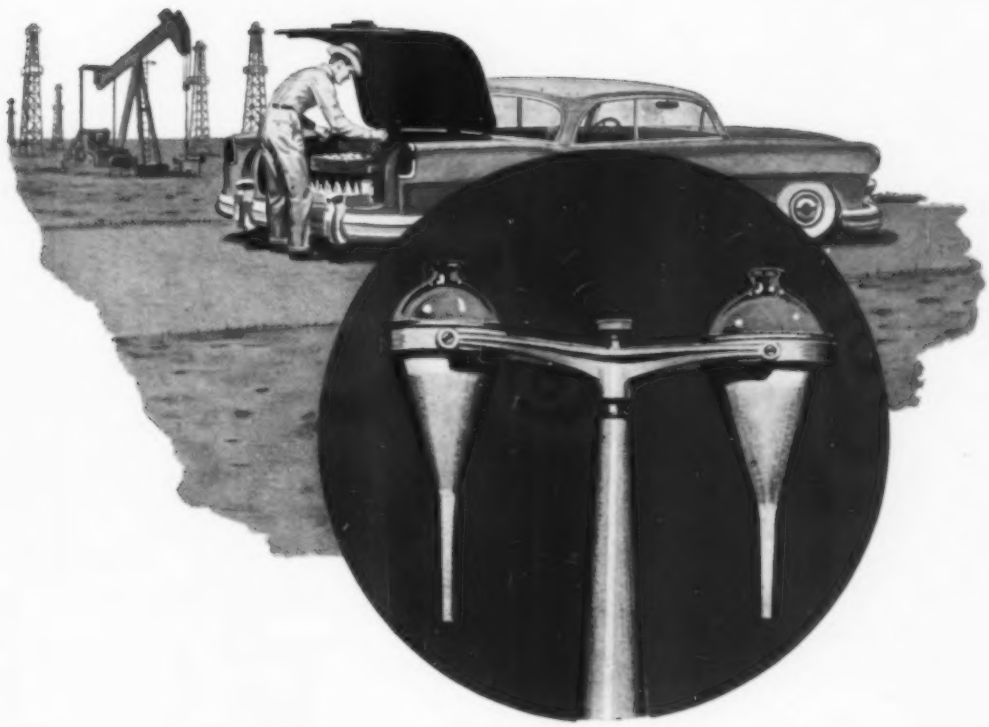

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TABLE 1. Field Tests — Selective Water-Seal Process.

	Formation	County & State	Previous treatments	Production before SWS	Production after SWS		Production change by SWS	Remarks
1.	Granite Wash (very permeable, fluid level cannot be lowered)	Gray, Texas	Fractured—oil Cement squeeze Acidized	2-3 bopd Over 200 bwpd	52 bopd 50 bwpd	3 days	+50 bopd 150 bwpd	SWS effective in well where fluid level could not be lowered with casing swab. Production after 2 weeks: 25 bopd, 52 bwpd.
2.	San Andres (tight intercrystalline porosity with random fractures, 2 zones)	Crockett, Texas	Fractured 10,000 oil 15,000 sand	6-10 bopd 290 bwpd	16 bopd 160 bwpd	1 mo.	+10 bopd —130 bwpd	SWS effective in native random fractures. Production after 7 months: 10 bopd, 160 bwpd
3.	San Andres (small vugs)	Howard, Texas	Acidized Fractured—oil 17,500 sand	Trace of oil 85 bwpd	.75 bopd 37.5 bwpd	1 mo.	+.75 bopd —47.5 bwpd	SWS effective in small vugs since over 50% water reduction constant until P. & A. over 1 month later.
4.	San Andres & Grayburg (tight intercrystalline porosity with random fractures, 8 zones)	Crockett, Texas	Fractured 80,000 water 70,000 sand	8 bopd 100 bwpd	21 bopd 5 bwpd	1 mo.	+13 bopd —95 bwpd	SWS effective after large fracture treatment using water. Production after 5 months: 5.52 bopd, 2.07 bwpd.
5.	San Andres & Grayburg (10 zones open)	Crockett, Texas		6 bopd 110 bwpd	8.27 bopd 4.14 bwpd	1½ mo.	+2.27 bopd —105.9 bwpd	SWS produced 96% decrease in water and 38% increase in oil production.
6.	San Andres (2 zones)	Crockett, Texas	Fractured 10,000 oil 15,000 sand	10 bopd 160 bwpd	30 bopd 70 bwpd	1 mo.	+20 bopd —90 bwpd	Water production decreasing with time. Production after 2 months: 16 bopd, 64 bwpd.
7.	Grayburg (3 zones)	Crockett, Texas	Acidized Fractured 60,000 water 60,000 sand	No oil 125 bwpd	7 bopd 5 bwpd	1 mo.	+7 bopd —120 bwpd	SWS was effective despite no oil production before treatment. Production after 2 months: 3.02 bopd, 3.32 bwpd.
8.	Grayburg (7 zones)	Crockett, Texas	Fractured 50,000 oil 50,000 sand	14 bopd 52 bwpd	17 bopd 16 bwpd	1 mo.	+3 bopd —42 bwpd	Production after 1½ months: 11.5 bopd, 16.5 bwpd.
9.	Delaware Sand (some fractures)	Ward, Texas	Fractured 20,000 oil 20,000 sand	2-4 bopd 100+ bwpd (flowing)	Trace of oil 90,000 cu ft/day gas No water	1½ wks	Trace of oil +90,000 cu ft gas No water	Oil saturation too low for continuous oil phase. SWS completely blocked a head of over 5000 ft of water in a flowing well.
10.	Spraberry (tight, clean, some fractures)	Borden, Texas	Fractured 20,000 oil 30,000 sand	No crude (1-2 bbl fractured oil pd) 85-90 bopd	No oil No water	2 wks.	No oil No water	SWS completely blocked a head of over 3000 ft of water in a well which could not be swabbed down.

fully treated unless the vugs and channels are sufficiently small to present a barrier to migration of the water droplets of the emulsion. In most cases, the size and extent of the vugs and channels are unknown.

Fracture systems. When oil is produced from an open fracture system rather than from matrix porosity, it is unlikely that sufficient constrictions in the flow channels will exist for this process to be effective. A different situation exists, however, in tight fractures where effective blocking can occur.

Shot wells. This type of well usually has a large cavity of unknown volume. It may have open fractures extending from the cavity. To attain a reasonable probability of treating all exposed permeable zones, a large volume injection is required.

In addition to the above situations, special attention must be given to heavily acidized and fractured wells. High permeability channels created by these operations are considered as extensions of the well bore and the water shutoff treatment must be designed to penetrate some distance into the exposed matrix permeability.

Life of Water Barrier

The strength and durability of the process are demonstrated in results of actual field tests. In West Texas, a Spraberry well which was fractured into water *and never produced oil* was treated to shut off the water. Before treatment, the well had over 3000 ft of water standing in the hole which could not be swabbed down. After treatment, the hole was pumped dry and remained so until a subsequent lease oil squeeze broke into and extended the fracture, resulting again in water production. Similarly, a 5000 ft Delaware sand well with a maximum oil saturation of less than 50 percent was flowing 100 bbl of water per day with about 2 percent oil. After treatment, the well produced 90,000 cu ft of gas per day with a trace of oil and no water. The well remained dry until it was plugged and abandoned about six weeks later. The operator had agreed before the treatment that this well probably did not have a continuous oil phase and that both water and oil would be blocked.

A two-zone San Andres well in West Texas was making 290 bbl of water and about 10 bbl of oil per day. Immediately after treatment the oil production rose to 16 bbl of oil with 160 bbl of water per day. Seven months after treatment the well was still making 10 bbl of oil and 160 bbl of water. This reduction of 130 bbl in daily water production was realized immediately after treatment and no increase in water has been noted to date.

Results obtained in these tests demonstrate the strength and permanence of the block created by this new water shutoff process. A number of representative field test results are tabulated in Table 1.

Treating Volumes Required

The volume of treatment required may vary widely according to each situation. Field tests reported in Table 1 average about 2500 gal of surfactant-oil solution. This treatment was displaced with about 1500 gal of oil in excess of the volume required to fill the well bore.

Other Applications

Obviously there are many possibilities for uses of this process other than those given above. Its inherent selectivity and ease of application make it attractive for use not only in oil wells but also in any situation where it is desirable to prevent the migration of water or aqueous liquids through permeable bodies. Although much has been accomplished in field testing this process, its development is still in its infancy and undoubtedly new applications and techniques will be uncovered.

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4. A. W. Garst, *Jour. Pet. Tech.*, November 1954.
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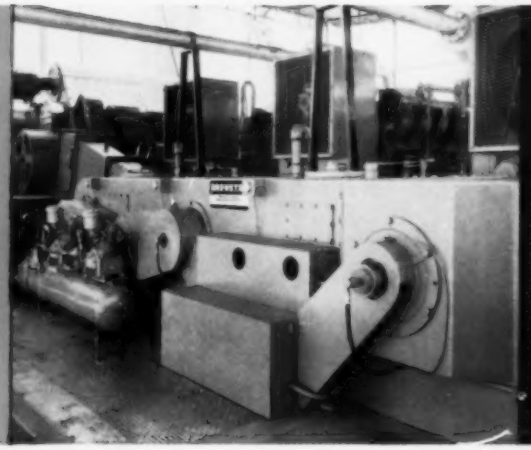

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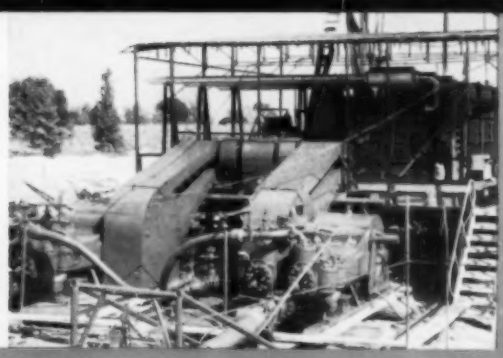

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New officers for AAODC. 1958 officers of the American Association of Oilwell Drilling Contractors, elected at the 17th Annual Meeting in Tulsa are, back row, left to right: Brad Mills, executive vice president, Dallas; J. J. Harrigan, vice president — Well Servicing, Oklahoma City; W. L. McClusky, secretary-treasurer, Dallas; Herbert Woolf, vice president — Cretaceous and Tertiary Basins, Tyler, Texas; B. A. Wales, vice president — Gulf Coast, Refugio, Texas; Lloyd R. Pickrell, vice president — Central Mid-Continent, Wichita, Kansas. Front row, left to right, Jack H. Abernathy, incumbent president, Oklahoma City; Marion S. Church, general counsel, Dallas; J. U. Teague, president-elect, Houston; Frank E. Frawley, national vice president, Tulsa, and B. F. Gilchrist, vice president — North and West Central Texas, Abilene. Not pictured are: Ray Wiley, vice president — Cable Tools, Carmi, Illinois; Don Johnson, vice president — New Mexico and West Texas, Midland; Don Slape, vice president — Illinois, Michigan, Indiana and Kentucky, Olney, Illinois, and Guy E. Keith, vice president — Rocky Mountains, Casper, Wyoming. The officers-elect will assume their new posts January 1, 1958, for a one-year term.

AAODC Seeks to Better Economical, Technical Position at...

17th Annual Drilling Contractors Meet

Engineer Jim Teague elected to succeed engineer Jack Abernathy as 1958 president, AAODC

FUTURE solutions to current economic and technical problems commanded the attention of members of the American Association of Oilwell Drilling Contractors attending their 17th Annual Meeting October 13-15 in Tulsa.

President Jack H. Abernathy, of Oklahoma City, keynoted the meeting at the first general session, when he called for drilling contractors to "compete cooperatively," to maintain quality standards in service, and a healthy business atmosphere.

Abernathy restated his "personal view that business for the next four or five years will not be booming for drilling contractors." Nevertheless, he added, "We can bid to keep our rigs up and pay our men rates comparable to those in the oil industry generally; we can study, work, listen and learn how to do a better job — and we can be prepared to meet any national emergency."

At a press conference, J. U. Teague of Houston, who was selected as Abernathy's successor as AAODC president, voiced similar views when he said, "Although drilling contractors are caught in a price squeeze today, the long-range outlook for the industry is good.

"Regardless of the highly competitive conditions now," Teague said, "hard work, thorough knowledge of the business and best service to the operator at lowest profitable price" were ways the contractor could get ahead.

Teague, president of Columbia Drilling Company and, like Abernathy, a graduate petroleum engineer, will assume his new office January 1, 1958, for a one-year term. Abernathy will continue in the presidency until the end of the year, as a result of board action which revised the national terms of office to coincide with the calendar year.

Teague is currently national vice president, and has been active in AAODC work for more than a decade. After graduation from Rice Institute in

1930, he worked for Humble Oil & Refining Company for ten years as a petroleum engineer, leaving to join Hogg Oil Company. He served 3½ years in the Navy in World War II. Teague organized Columbia Drilling Company in 1949. In previous AAODC posts, he was chairman of the Rotary Drilling Committee for three years, chairman of the Houston Chapter, Gulf Coast vice president, and director.

Supplier Views Aired

Each of the speakers at the three general sessions echoed the campaign to hold costs to realistic levels and at the same time increase technical efficiency.

Rainey Elliott, president of Jones & Laughlin Supply Division, Tulsa, told the drillers that a "real challenge" for both contractors and suppliers exists to meet the potential of the next ten years.

Citing industry forecasts, Elliott predicted that during the next ten years total wells drilled will increase by 49.5 percent, exploratory wells by 48.1 percent, average depth by 13.6 percent, and dry holes by 59.1 percent. He said meeting these requirements would call for the contractors' cooperation to "try to reverse the trend of expensive and sometimes foolish practices of service that exist." Specifically, he pointed to the problem of excessive rig calls, and also referred to equipment trade-ins and credit practices as areas in the supplier-contractor relationship that could be improved.

Former president of the Petroleum Equipment Suppliers Association, Elliott said the oil industry expects suppliers to "improve our equipment and services, drilling techniques and managements to fulfill our commercial and moral obligation. It is also expected that such performance be rewarded by a fair return in profits.

"Contrary to the rather widespread belief, the margin of profit earned in our industry is inadequate, and is to the point of being unhealthy," Elliott declared. "As an industry, we earn the small average dividend of 1.74 percent of our total income dollar. On the other hand, the average earnings plowed back into the building-up of the companies to properly serve the oil industry is 4.76 percent of our income dollar."

The drillers also heard a forecast of future drilling activity by economist John C. Casper, of the *Oil & Gas Journal*, who estimated that production and reserve needs for the next nine years will call for almost 645,000 new wells drilled.

J. U. Teague, president of Columbia Drilling Company, Houston, Texas, was elected 1958 president of the AAODC. Teague will take over the presidency January 1, 1958, from Jack Abernathy.

Technical Study Reports

In the technical session on the closing day, the AAODC members learned of progress by two association subcommittees, and heard a report by E. A. Studer, chief engineer for The Baylor Company, Inc., Houston, on applications of the magnetic coupling and the magnetic particle brake.

M. M. Brantly, president of Brantly Drilling Company, Midland, and chairman of the AAODC-API joint subcommittee, said cataloged records of air and gas drilling are now available as a service to the industry to oil companies planning new drilling operations. The records, being assembled in the office of Technical Drilling Service in Midland, include formation logs of air drilled wells, electric logs, well record cards, and other information on actual operations.

"The records are approaching the point where, at least in the Permian and Delaware Basins, they can be quite helpful to those contemplating air or gas drilling," Brantly said. He pointed out that any request for information should pin-point the location rather than describe it by general area.

The AAODC weight-speed vs penetration studies were reported by a panel of engineers who had worked on initial tests at two drilling operations in the Dora Roberts field, Ector County, Texas. Subcommittee Chairman E. L. Decker, president of Martin-Decker Corporation, Long Beach, said the group's goal is "simple, down-to-earth answers for the man whose job it is to make hole."

H. B. Woods and E. M. Galle, Hughes Tool Company, Houston, said, "Over-all averages of the effect of weight showed approximately a straight line relationship between weight and drilling rate, with a slope such that within the range of weights investigated, a 50 percent increase in weight will give about a 65 percent increase in drilling rate."

The speed factor tests, analyzed by J. E. Eckel and D. S. Rowley, The Carter Oil Company, Tulsa, indicate that drilling rate does not increase proportionately with rotary speed.

"The flattening of the rotary speed vs penetration rate curve at higher speeds seems to indicate that when bit weight is held constant, individual tooth contacts at higher speeds are not as effective in removing the formation as contacts at lower speeds," Eckel and Rowley reported.

Further tests will be made to determine the most economical weight and speed to carry in specific zones in specific areas, Decker pointed out in his closing remarks.

Forecast for Congress

Senator Robert S. Kerr, in his address at the concluding banquet, pledged a fight for mandatory restrictions on oil imports at the next Congressional session. He also said that chances are good that the Harris-O'Hara natural gas bill will be passed.

Awards Conferred

Three men of the drilling industry were presented special awards at the meeting.

C. B. Webster, of Houston, and Austin Mosley, of San Antonio, both AAODC chapter chairmen in their respective regions, were singled out for contributions to the drilling association.

W. P. Woods, toolpusher for Oil Production Maintenance, Inc., Houston, was given special recognition for his safety record in 1956. Woods' certificate cited "no lost time, no down time, and no reportable medical injury" to any member of the crews under his supervision during the entire year.

1958 Officer Slate

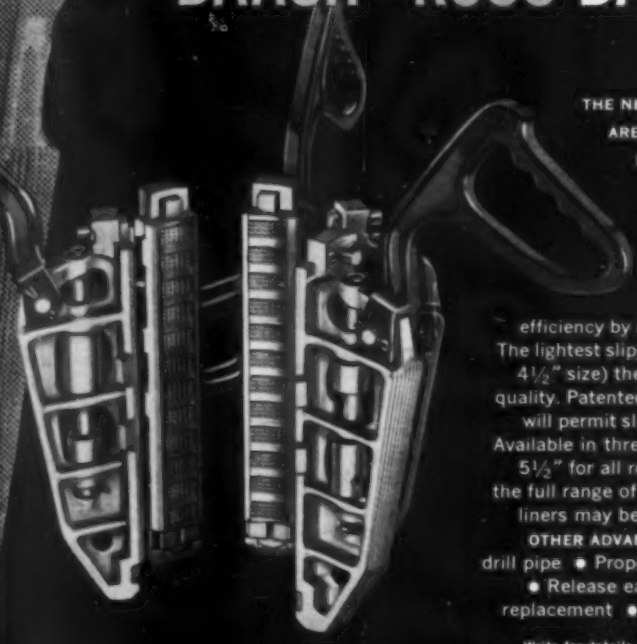
Frank E. Frawley, Frank Frawley Drilling Company, Tulsa, was elected national vice president to succeed Teague in 1958.

Other vice presidents named were: Ray Wiley, Ray Wiley Drilling Company, Carmi, Illinois — Cable Tools; Don Johnson, Carl B. King Drilling Company, Midland — New Mexico and West Texas; J. O. McFaddin, J &

keep 'em
turning to
the right
with quality
engineered

BAASH-ROSS BANTAM SLIPS

THE NEW BAASH-ROSS TYPE "G" BANTAM SLIPS ARE AN OUTSTANDING ACHIEVEMENT IN DESIGN, ENGINEERING AND PRODUCTION.



Weighing ⅓ less than old types, they help keep rotaries "turning to the right" with maximum efficiency by reducing crew fatigue to a minimum. The lightest slips in the field (only 96 lbs. for the 4½" size) they still maintain traditional Baash-Ross quality. Patented grooved slip-back construction will permit slips being used without back-up tongs. Available in three body sizes—2⅞", 4½" and 5½" for all rotary tables. Liner segments cover the full range of sizes from 2-1/16" to 5½"; liners may be inverted to balance wear.

OTHER ADVANTAGES • 7500 ft. (approx) 4½" drill pipe • Properly engineered gripping surface • Release easily • Easy liner segment replacement • Long liner wear

Write for details on all types of slips or see the Composite Catalog.

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DIVISION OF JOY MANUFACTURING COMPANY

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New York, N. Y.; Greenock, Scotland; London, England; Paris, France; Maracaibo, Venezuela; Buenos Aires, Argentina.

M Drilling Company, Los Angeles — California; Don Slape, Don Slape Drilling Company, Olney, Illinois — Illinois, Michigan, Indiana and Kentucky; B. A. Wales, J & C Drilling Company, Refugio, Texas — Gulf Coast; Lloyd R. Pickrell, Pickrell Drilling Company, Wichita, Kansas — Central Mid-Continent; Guy E. Keith, Pioneer Drilling Company, Casper, Wyoming — Rocky Mountains; J. J. Harrigan, Standard Drilling Company, Oklahoma City — Well Servicing; Herbert Woolf, Woolf & Magee, Tyler, Texas — Cretaceous and Tertiary Basins; B. F. Gilchrist, Gilchrist Drilling Company, Abilene — North and Central West Texas.

Re-elected were W. L. McClusky, M. J. Delaney Company, secretary-treasurer; Brad Mills, executive vice president, and Marion S. Church, general counsel, all of Dallas.

Incumbent President Abernathy sounded the challenge to the AAODC officers-elect and members when he referred to past contributions of the association as a "prologue to the future," and called on members to further AAODC work in research, education and training. ★ ★ ★

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LONG LIFE

Heavy-Duty

POWER TAKE-OFF

Designed to meet the needs of Oil Field and other rugged service—this ROCKFORD Extra Heavy-Duty POWER TAKE-OFF

- Eliminates the Pilot Bearing
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Insure longer work life and reduce down-time with this NEW extra heavy-duty ROCKFORD POWER TAKE-OFF.

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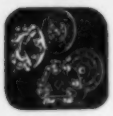
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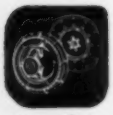

Heavy Duty Over Center

Power Take-Offs

Speed Reducers

CLUTCHES

Creole Marks Barge Redefinition

Creole Petroleum Corporation's extensive construction program has been marked by a full year of frequent additions to its offshore drilling fleet. These additions are excellent examples of the oil industry's new definition of the word "barge." Creole has in operation nearly every type unit in the Lake Maracaibo area of Venezuela.

With the petroleum industry's advancements in offshore and coastal drilling, the word "barge" has lost its original connotation. Today, rather than designating bulk carriers only, the term "barge" is freely applied to almost any non-propelled vessel that provides a working area for one or more of the functions of oil well drilling or servicing. The series of barges constructed by Avondale Marine Ways, Inc., for the use of Creole in the Lake Maracaibo area of Venezuela are an excellent example of this latter category.

Three of these barges are of the deck cargo type, 110 by 40 ft, designed primarily for the transportation of materials to various locations on, and adjacent to, the lake.

Four other deck cargo barges, 110 by 50 ft, have been constructed for general well servicing in the Tia Juana district of Lake Maracaibo. Each of these contains six ballast tanks, two oil test storage tanks, four void compartments, a 12-in. double bottom beneath the reserve mud tank, active mud, oil test storage and fuel oil tanks.

Three other barges, 100 by 50 ft, were also constructed for similar application and differ from the former barges in dimensions as well as a slight difference in the equipment installed.

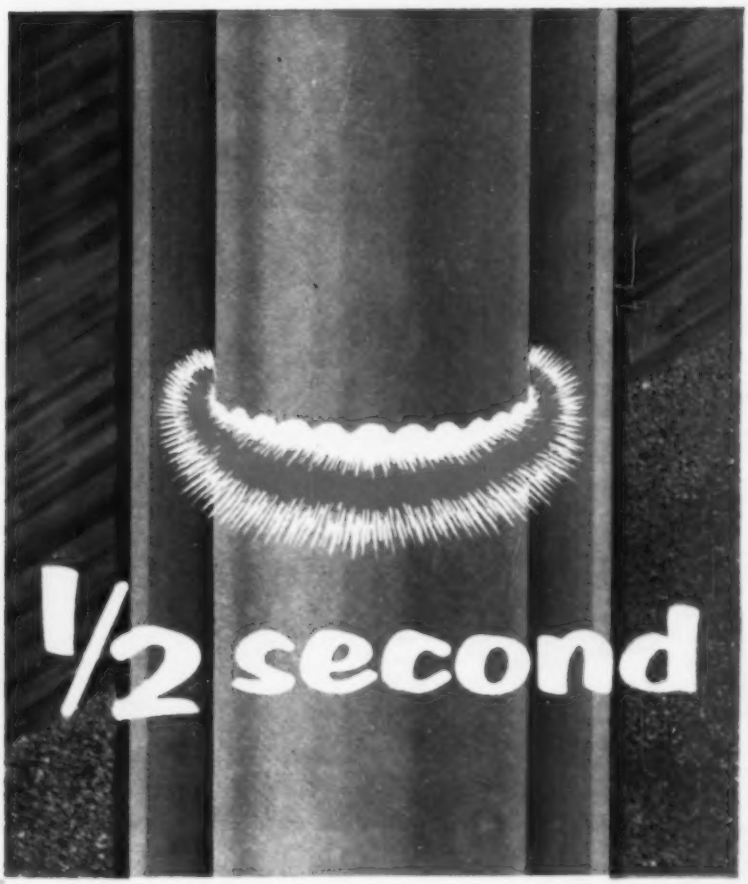
The remaining two barges, 100 by 50 ft, are of comparable construction but will be used for cement coating pipe on location.

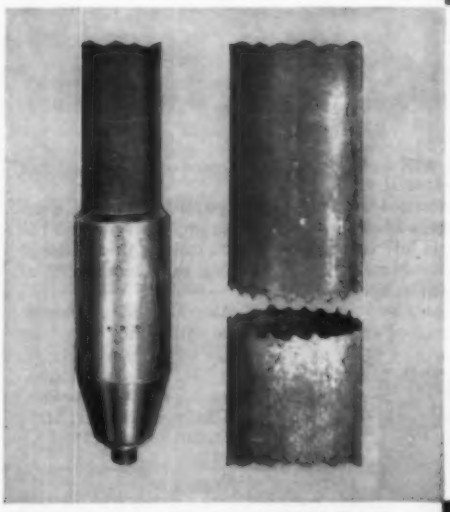
Each of these barges will carry four hoppers, another four will be in transit between the barge and the bulk station, and four more will be at the bulk station in readiness for transporting to the job site.

This coated pipe is used to form a protection at existing wells. One barge will service the Lagunnillas district, while the other will handle the Tia Juana district of Lake Maracaibo.

With the exception of the three 100 by 40 ft deck cargo barges, built to American Bureau of Shipping classification for short coastwise service, these barges are intricate floating workshops. In the oil industry they are discussed as "barges"; but, when one considers the intricacy of the installation, the term seems hardly appropriate. ★ ★ ★

Cuts Tubing in ½ second





Above, left—cutter head of the McCullough Chemical Tubing Cutter showing the orifices from which the chemical is ejected under enormous pressure, cutting the tubing in a fraction of a second.
Above, right—sample of 2½" tubing cut by Chemical Cutter. Note the absence of flare, burrs, or distortion of any kind on either the O. D. or I. D.

McCULLOUGH CHEMICAL CUTTER

This "split-second" Chemical Tubing Cutter applies the enormous power of the halogen fluorides, under closely controlled conditions, to cut through tubing in only ½ second. It will save more than 80% of the rig time usually required to cut tubing by mechanical methods.

McCullough's Chemical Tubing Cutter, run on an electric wire line, makes a clean, flare-free cut. It will not damage the casing even though the tubing be as close as 1/64". The entire operation is junk-free, since no part of the cutter is expendable.

This revolutionary new service will gain you a substantial saving in both time and money on that next tubing job—ask your McCullough Service Engineer. Available for 2" and 2½" tubing at all McCullough Service Locations.

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With Confidence—
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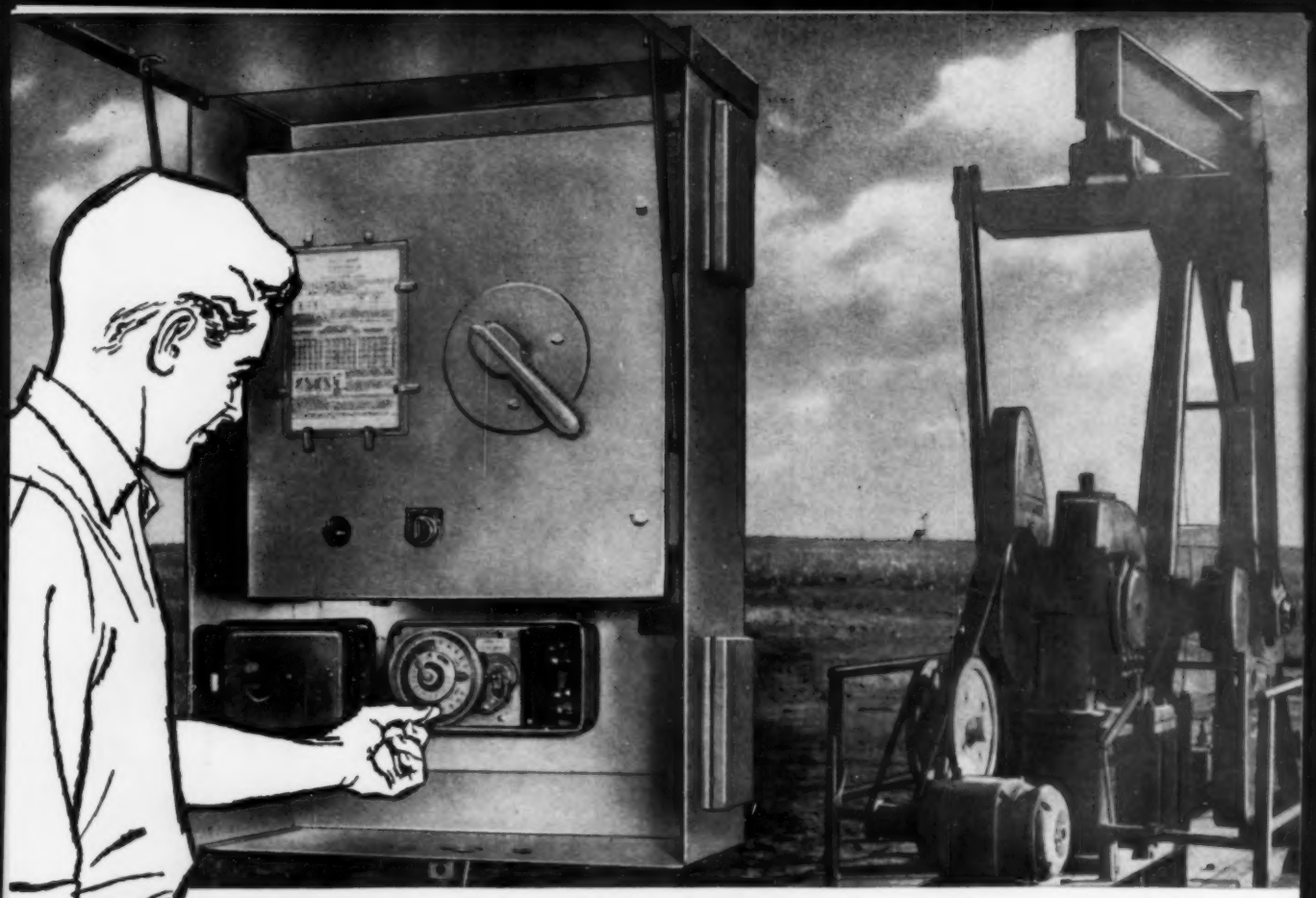

"Practically thinks for itself"

The new Cutler-Hammer Three-Star Oil Well Pumping Control has performed so successfully and proven so completely dependable that the leading oil field men everywhere insist on C-H control for all their pumping wells and accept no substitutes. Ask these men why and they will tell you, "That new C-H three-star control beats them all. No matter how tough it gets, our pumps keep pumping; and that Supertimer practically thinks for itself." Your first pumping well equipped with Cutler-Hammer control will prove to you what these men know... Cutler-Hammer Three-Star Oil Well Pumping Control will out-perform, out-protect, out-last and serve better than all others.

This control has *everything*, particularly the engineered dependability so vital in any automation... nothing is left to chance. Insist on the finest, insist on Cutler-Hammer... leading manufacturer of *automation* control.

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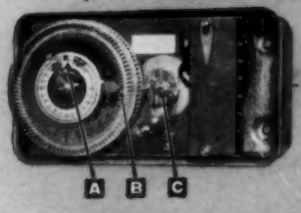
New CUTLER-HAMMER Supertimer



This is *automation* in action. You pre-set the Supertimer to meet your field allowable and the control will do the rest, automatically. It starts, stops, restarts and cycles indefinitely, precisely according to your schedule. If a power outage occurs, any number of C-H controlled pumps can be restarted in an exact sequence to avoid overloading the power lines on inrush. Unfortunate coincidental starting of even two pumps is impossible.

A Sets the precise restarting time delay from zero to 180 seconds. This is exclusive with the Supertimer—random starts or coincidental starts of even two pumps are impossible.

B Sets the daily pumping schedule—pull a tab for each fifteen minutes of pumping, space them through the daily 24 hour period as desired.

C Sets the weekly pumping schedule—1, 2, 3, 4, 5, 6 or 7 days per week as desired.

COMPLETE PROTECTION
The control is protected against lightning with exclusive, advanced-designed lightning arresters; and the three coil overload relay protects the pump motor from overloading and dangerous single phasing which often results from lightning.

CHIMNEY DRAFT VENTILATION
The heat-reflecting, aluminized enclosure insures a constant circulation of air... no nuisance tripping because of trapped heat.

DUST SAFE CONTACTS
Dust-Safe vertical contacts stay clean and eliminate the necessity of contact replacement common to other designs.

Venezuelan operators get cementing and formation data from

Radioactive Tracer Logging with Oil Well Cementing

One-trip method gives: (1) cement tops; (2) zones taking cement; (3) cement channeling; (4) depths; (5) location of gas sands; and (6) indication of porosity

Russell G. Norelius
Petro-Tech Service, C.A.
Caracas, Venezuela

DEVELOPMENT of short half-life activated isotope tracers has made possible a radioactive logging method that indicates on a single trip in the well (1) tops of cement, (2) zones taking cement, (3) cement channels, (4) depths, (5) location of gas sands, and (6) porosity. No base logs are required, and other nuclear logging devices may be run later in the life of the well.

Location of a cement top by a radioactive tracer has been used for many years. The earliest material to be added to cement was carnotite which has a half-life of over 5000 years. This meant that a well to which carnotite had been added was forevermore contaminated insofar as logging the well with nuclear devices was concerned. Recent developments in nuclear science have made activated isotopes with a short half-life available for use as tracers. Radiation from these tracers is recorded on the gamma-ray curve. The radioactive material presently being added to cement in Venezuela has a half-life of 75 days. After 500 days, activity of this material is reduced to one percent of its original value; a sufficiently low radiation level so that other nuclear logging devices may be run in the well without being influenced to a practical degree by the tracer.

Because of the design of early instruments, the neutron log was also affected by the radioactive material when added to the cement in large quantities. For this reason, it was necessary to run a base log prior to the addition of tracer material, followed by a second log after cementing to locate the tracer. This was an inefficient and expensive procedure.

In recent years new sub-surface instrumentation has been developed that permits recording a neutron curve which is insensitive to natural gamma rays emitted from the formation or from radioactive tracers added to the bore hole. This development permits the use of larger quantities of tracer material in the cement slurry to aid in locating cement tops and other anomalies without detrimentally affecting the neutron curves. Thus with one trip in the hole the operator can obtain cement tops, zones that are taking cement, and cement channeling from the gamma ray log, and at the same time the neutron log gives a depth check, location of gas sands and an indication of porosity. The base log is not required, resulting in reduced service cost and rig time.

Type of tracer used. The most suitable tracer for locating cement tops is a

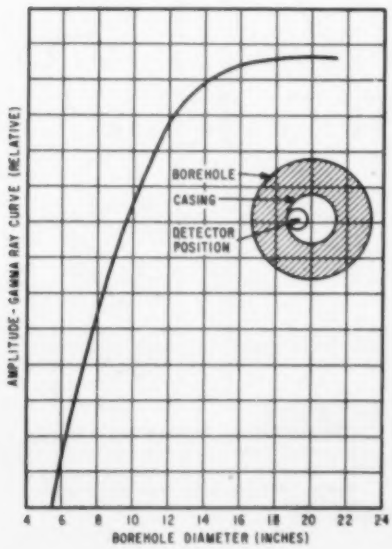

AMPLITUDE - GAMMA RAY CURVE (RELATIVE)
BOREHOLE
CASING
DETECTOR POSITION
4 6 8 10 12 14 16 18 20 22 24
BOREHOLE DIAMETER (INCHES)

FIG. 1. **Gamma ray amplitude** versus radioactive cement thickness with casing centered in the borehole.

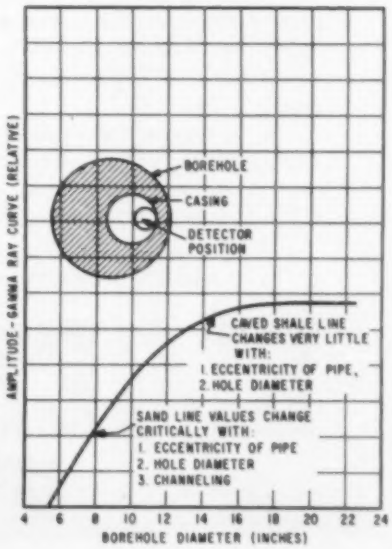

AMPLITUDE - GAMMA RAY CURVE (RELATIVE)
BOREHOLE
CASING
DETECTOR POSITION
CAVED SHALE LINE CHANGES VERY LITTLE WITH:
1. ECCENTRICITY OF PIPE,
2. HOLE DIAMETER
SAND LINE VALUES CHANGE CRITICALLY WITH:
1. ECCENTRICITY OF PIPE
2. HOLE DIAMETER
3. CHANNELING
4 6 8 10 12 14 16 18 20 22 24
BOREHOLE DIAMETER (INCHES)

FIG. 2. **When casing not centered** in borehole, this curve shows the gamma ray amplitude versus radioactive cement thickness.

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His modern mobile laboratory, detailed crew direction, and complete log interpretation are your guarantees of greatest accuracy and minimum rig time. Added value: Elgen's lowest price schedules.

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water soluble material called CO-6. Advantage of this tracer is that it can be mixed homogeneously throughout the cement column. This even distribution aids in the interpretation of the resulting tracer log.

A second type material, called CT-6,

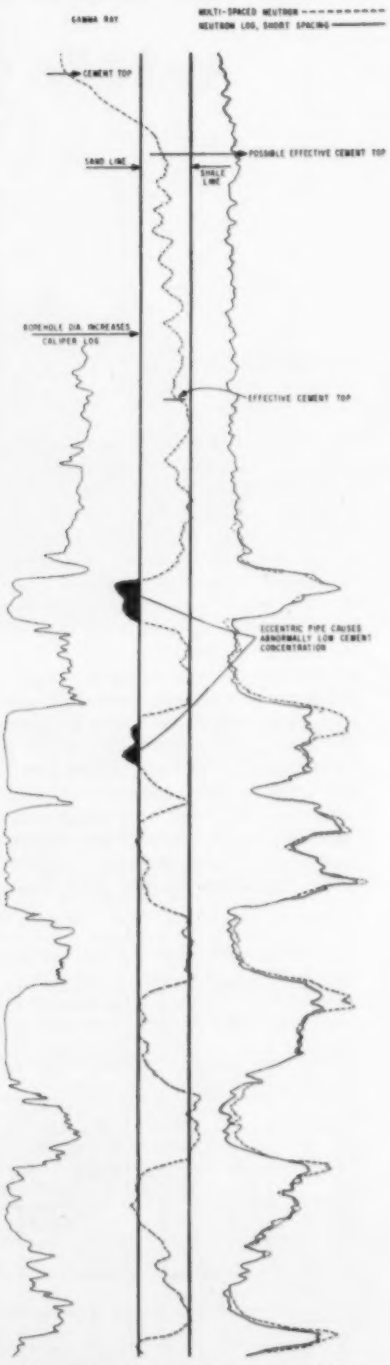
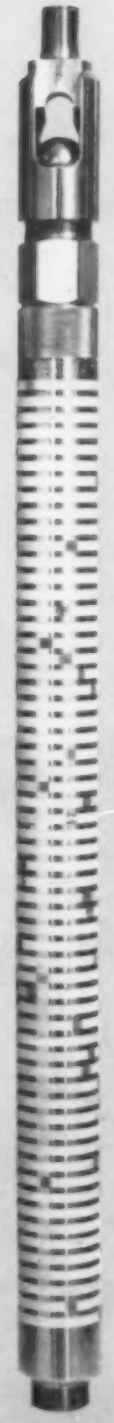


FIG. 3. **Effective cement top** is readily interpreted from this tracer log using CO-6 water soluble tracer. This log taken in an area where there has been appreciable caving in the shales.

(Continued on page B-121)

Metal to Metal Wear...

is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.



The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

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Manufacturer

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Another Jet Research Center
development of the
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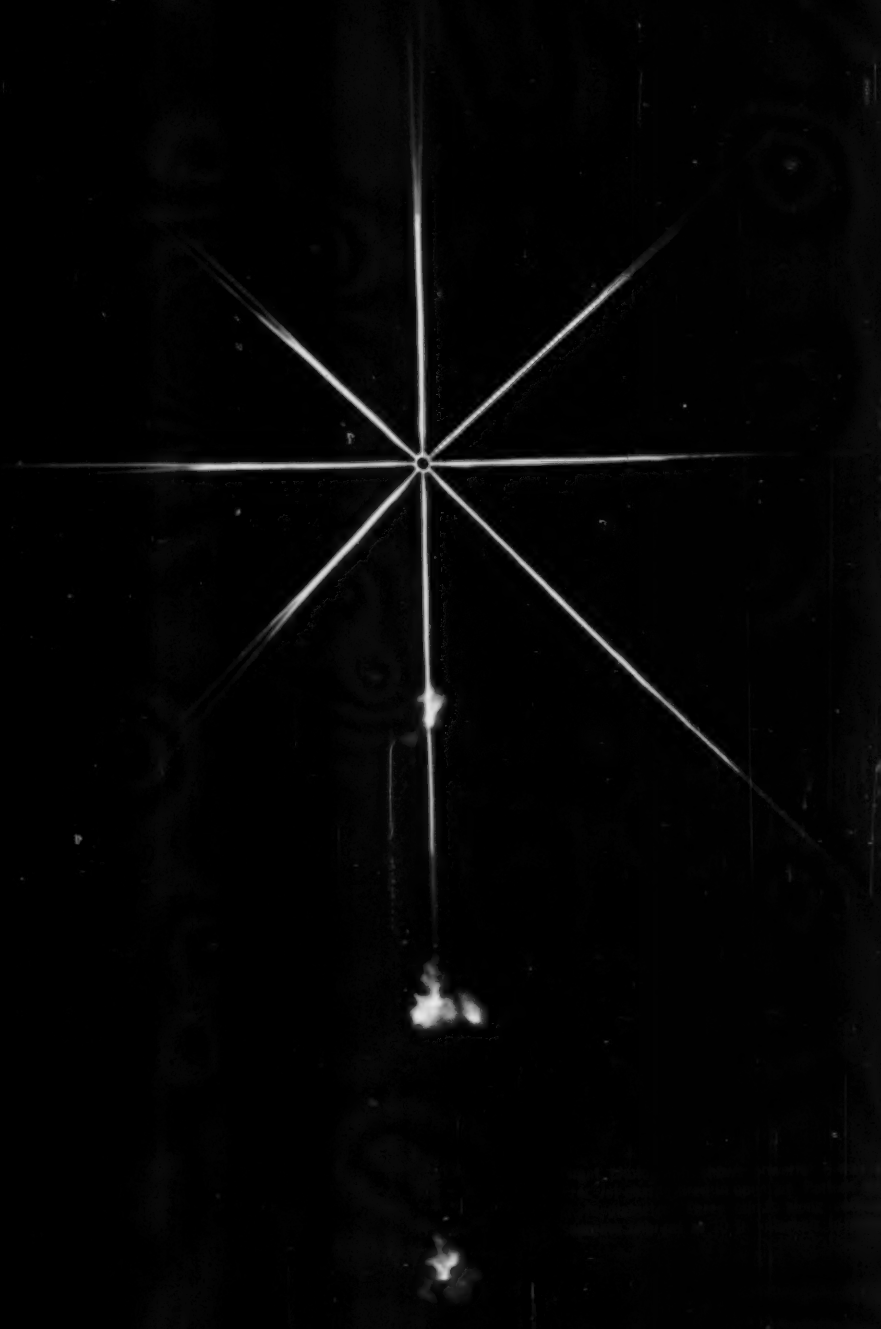

8-way barrier jet

cracks deep horizontal fractures

FRAC-JET*

WITH THIS NEW Frac-Jet you can place fractures *where you want them* and start deep horizontal fissures which conventional hydraulic fracturing can extend and widen. Eight high-velocity barrier jet charges at 45° phasing on the same plane are sealed in an aluminum alloy case. This pattern fires simultaneously.

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Diagram of Frac-Jet construction. Note barriers at base of each charge. Special aluminum alloy case resists highest well pressures yet shatters into small uniform fragments upon detonation.

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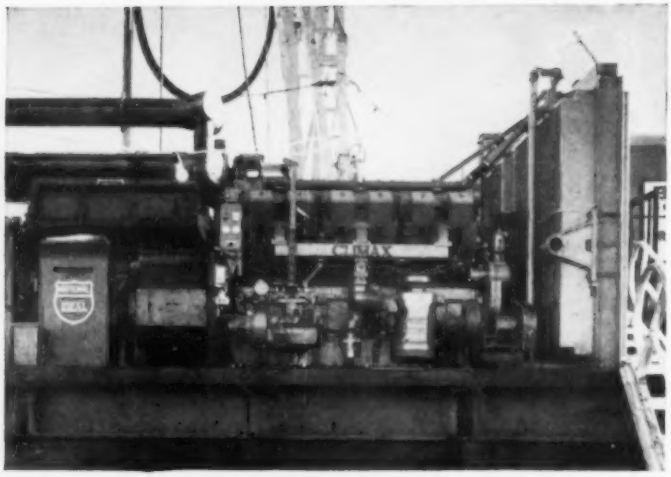
GREATER PERFORATING POWER THROUGH RESEARCH



BIGGEST VALUE IN THE ENGINE INDUSTRY

FOR POWERING RIGS

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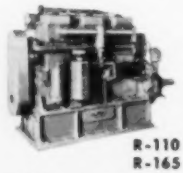
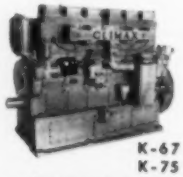
Model	No. of Cyls.	Bore and Stroke	Cu. In. Displ.	Pump and Drilling (Continuous Duty)						Hoisting (Intermittent Duty)						
			(2)	600	700	800	900	1000	1100	600	700	800	900	1000	1100	1200
R-110	4	6⅛x7	824	52	62	71	79	86	91	59	70	80	88	96	103	108
R-165	6	6⅛x7	1238	81	93	105	117	127	135	91	105	117	131	143	152	160
K-67	6	7x7	1616	110	129	145	161	176	188	124	145	164	181	197	212	225
K-75	6	7½x7	1855	126	146	166	185	204	218	142	166	187	209	230	245	260
V-80	8	7x7	2155	140	165	188	210	230	246	158	185	211	236	258	277	289
V-85	8	7½x7	2474	164	194	223	246	266	284	184	219	250	278	300	318	333
V-122	12	7x7	3232	217	258	293	324	353	378	244	290	330	364	398	426	442
V-125	12	7½x7	3711	242	292	340	384	417	442	272	328	383	432	469	498	520

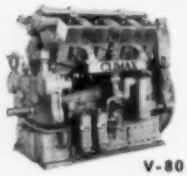
(1) These are continuous duty ratings on standard units that include a radiator and fan.
(2) R.P.M.



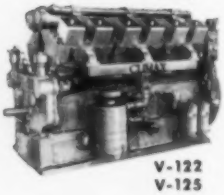
R-110
R-165



K-67
K-75



V-80
V-85



V-122
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Cause, Prevention, Evaluation and Cure of

Formation Damage

The degree of formation damage and its effect are basic considerations in well treatment and determine the well's ability to produce

Carl Gatlin
State College, Pennsylvania

THE degree to which formation permeability in the immediate area surrounding the well bore is, or may be, altered is of considerable importance due to its strong effect upon well productivity. Permeability of this relatively thin, altered zone may be either greater or less than that of the remaining bulk of the reservoir. Permeability reductions are due to the damaging effects of the drilling fluid, cement, or other materials which contacted the sand face during drilling and/or completion operations. Increased permeability in this zone is normally obtained from some type of stimulation technique such as acidizing or hydraulic fracturing.

The effect of this altered veneer or "skin" has been quantitatively expressed as the "skin effect."[1,2] The numerical value of the skin effect is the additional pressure drop necessary to cause fluid flow through the altered zone as compared with the same zone in its original condition. Therefore its magnitude depends on both the permeability and radius (depth of invasion) of the altered zone. A positive skin effect denotes an impaired permeability condition while a negative value signifies permeability improvement in the altered zone.

It has been shown in numerous publications that evaluation of the skin effect or other related factors is extremely useful in analyzing well completion effectiveness and/or the need for stimulation. This discussion will be concerned with the cause, prevention, evaluation and cure of formation damage around bore holes.

CAUSES

Formation damage is caused by the invasion of foreign fluids and/or solids into the exposed section adjacent to the well bore. Generally the drilling mud is the main source of such contaminants although cement invasion may be a considerable detriment in some cases. Materials used in stimulation treatments may also have some undesirable effects which partially nullify their beneficial actions. It is commonly recognized that formation damage is due to either or both liquid and solid penetration.

Liquid Invasion

The susceptibility of a formation to damage by foreign fluids is largely dependent on its clay content. Dirty sands are generally quite sensitive to the filtrate from fresh water base muds which allows hydration and swelling of interstitial clay particles. Saline filtrates cause less of this trouble and may in fact reduce particle size and increase oil permeability in some cases. This latter effect was noted by Nowak and Krueger[3] in their studies of the effects of various mud filtrates on the permeability of sandstone cores. It was shown in these tests that polyvalent salts, such as calcium chloride and aluminum chloride, did not permanently damage permeability as much as did sodium chloride solutions.

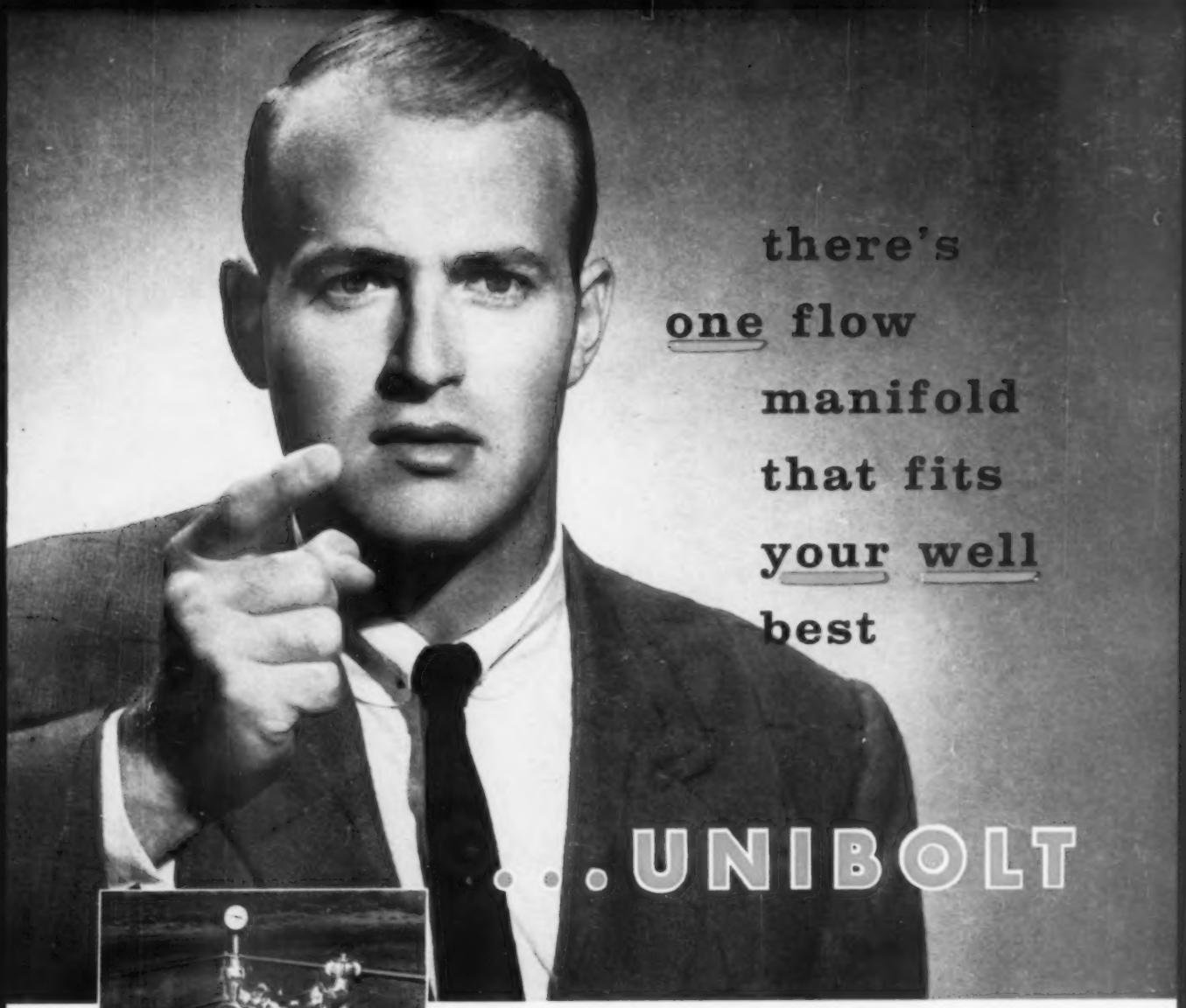
These effects were explained in terms of ion exchange as follows: The clay content in these California cores was presumably a sodium type. Thus, sodium ions were initially present to neutralize the surface charge of the individual particles. When contacted with the calcium chloride filtrate some of the sodium ions were replaced by calcium in the ratio of two sodium for one calcium. This resulted in clay particle shrinkage and hence less permeability reduction. Therefore it may be surmised that clay swelling problems depend on the interaction between the particular clay and filtrate involved.

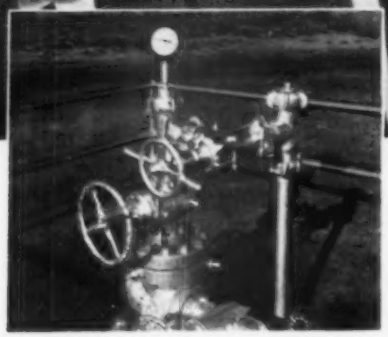
Another effect of filtrate invasion in dirty sands is that the interstitial clay particles may shift position as the increased water saturation gives them freedom of movement. This was proposed by Bertness[4] based on the assumption that clay fines are water-wet in the reservoir. The movement of such particles enables them to block or obstruct pores and results in permeability reduction.

Other possible effects of foreign fluid invasion are:

1. Emulsification with formation fluids — resulting in highly viscous mixtures and capillary blocking by insular bubbles (Jamin effect).
2. Precipitation of solids — insoluble salts and asphaltic or wax particles.
3. Reduction of relative permeability by the presence of a third immiscible fluid — for example, consider a gas sand which originally contains only gas and water. If this section is drilled or stimulated with an oil base fluid, some invasion will occur. When gas production begins, some of this oil will backflow and clean up; however, some will remain as an irreducible or immobile saturation. This reduces the permeability to gas and hence the productivity of the well.
4. Water-blocking — this is a rather general term pertaining to the rock's capillary retention of a wetting fluid, commonly water. The pressure necessary to expel such a fluid depends largely on the pore size of the rock involved. In this regard the swelling of clays and precipitation of solids reduce pore size and hence aggravate the problem.

The effect of a particular fluid on a specific formation is difficult to evaluate since each case is somewhat unique. The best rule is to use completion fluids as much like the forma-





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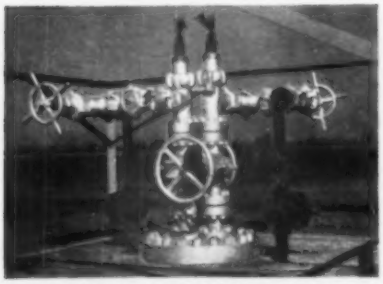

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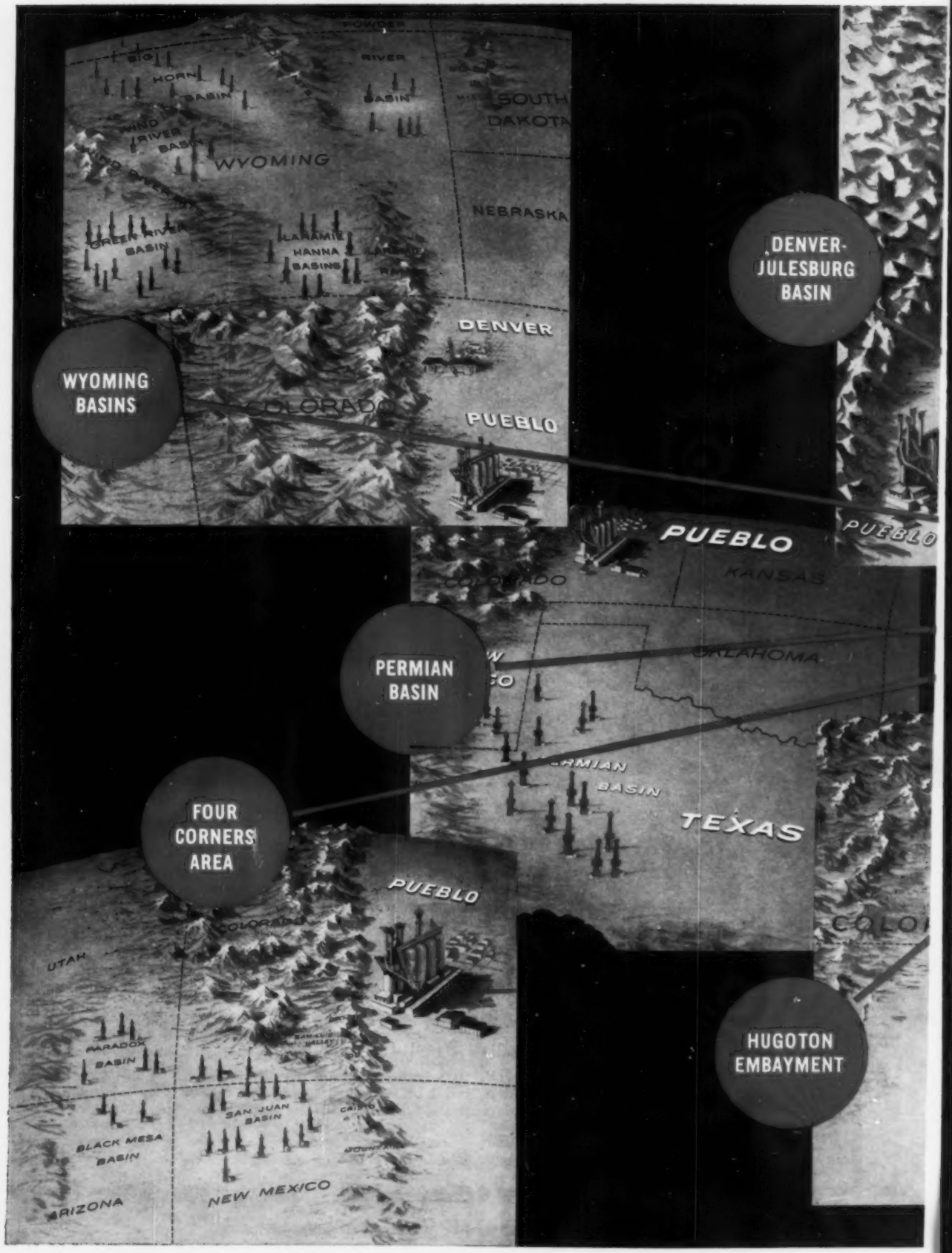

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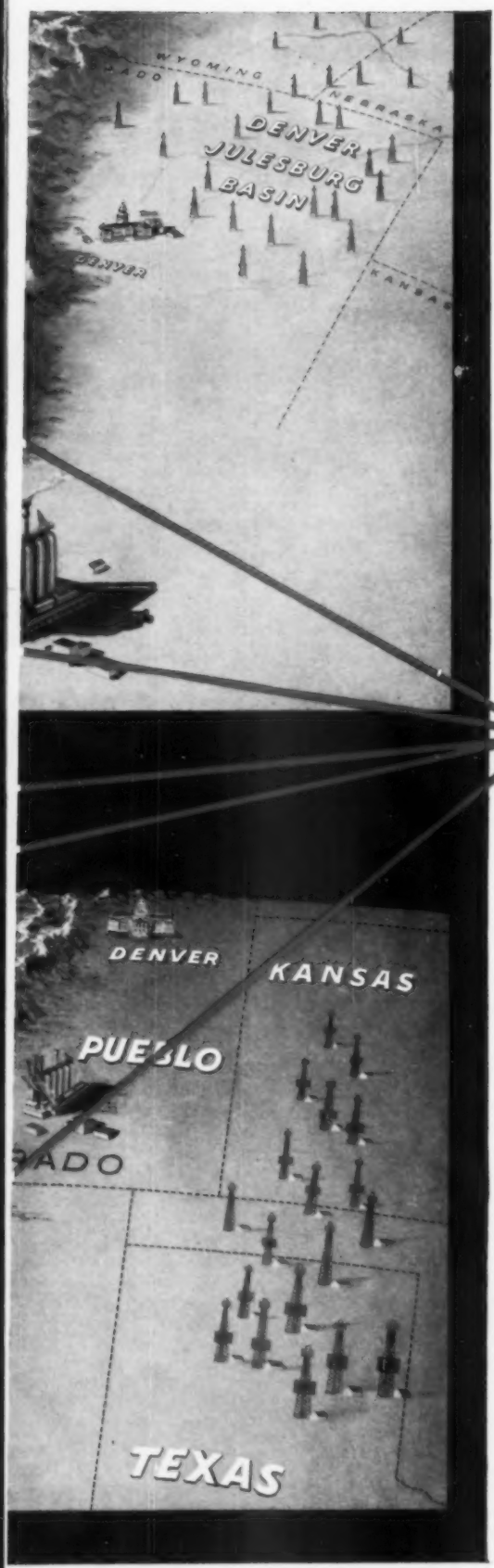

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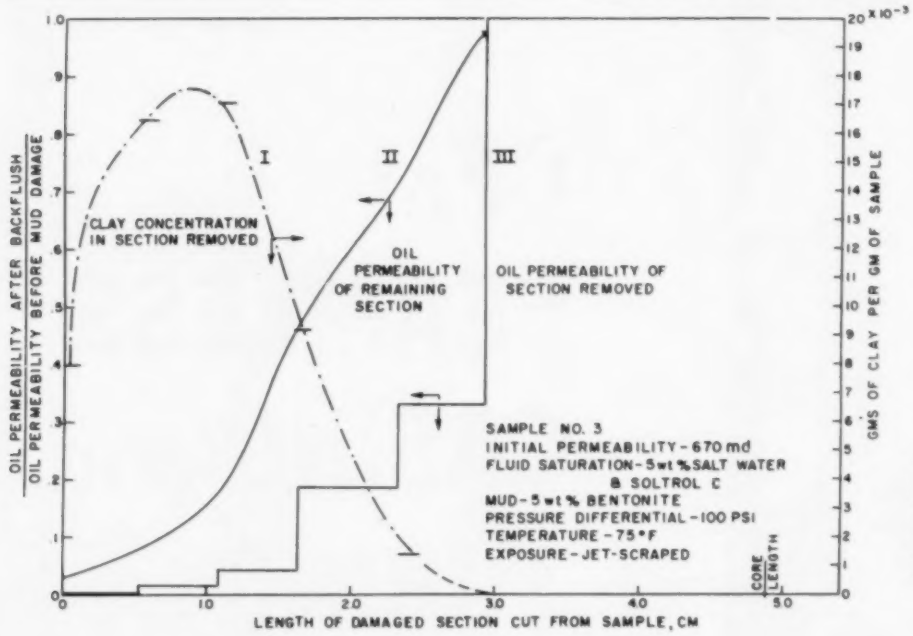

OIL PERMEABILITY AFTER BACKFLUSH / OIL PERMEABILITY BEFORE MUD DAMAGE
GMS OF CLAY PER GM OF SAMPLE
I
II
III
CLAY CONCENTRATION IN SECTION REMOVED
OIL PERMEABILITY OF REMAINING SECTION
OIL PERMEABILITY OF SECTION REMOVED
SAMPLE NO. 3
INITIAL PERMEABILITY - 670 md
FLUID SATURATION - 5 wt % SALT WATER & SOLTROL C
MUD - 5 wt % BENTONITE
PRESSURE DIFFERENTIAL - 100 PSI
TEMPERATURE - 75 °F
EXPOSURE - JET-SCRAPED
CORE LENGTH
LENGTH OF DAMAGED SECTION CUT FROM SAMPLE, CM

FIG. 1. Ratio of damaged permeability to original permeability of an alundum sample exposed to a 5 percent bentonite mud. After Glenn and Slusser[7] courtesy AIME.

tion fluids as possible. In general the preferred order of completion fluids is lease crude oil, other oils, salt water, and finally fresh water. Air and/or gas are excellent drilling fluids in those areas where they can be successfully applied.

Solid Invasion

It has been recognized that the invasion of solid particles may also be a considerable source of formation damage. The entry of solids into a rock requires that the particles be smaller than the pore openings. An extreme case of whole mud invasion is the loss of circulation.

Various publications have analyzed the extent of mud solid invasion and its effect on formation permeability.[2,5,6,7] The observed permeability decreases are believed due to two basic causes:

1. Plugging of internal pores by the solid particles.
2. Reduction of effective pore radius with consequent increase in interstitial water content and reduction in permeability to oil or gas.

The depth of solid particle invasion is of course smaller than that of the filtrate. Krueger and Vogel[6] report invasion depths up to 12 in. or more in 350 to 550 md cores exposed to mud for five days. Also the severity of damage decreases with distance from the well bore as shown by the Glenn and Slusser[7] experiment depicted in Fig. 1.

To this point we have considered only what may happen within the damaged zone after its invasion by the contaminating materials. Further appraisal of the cause of such invasion requires a basic look at the general filtration behavior of fluid-rock systems.

Effect of Mud Filtration

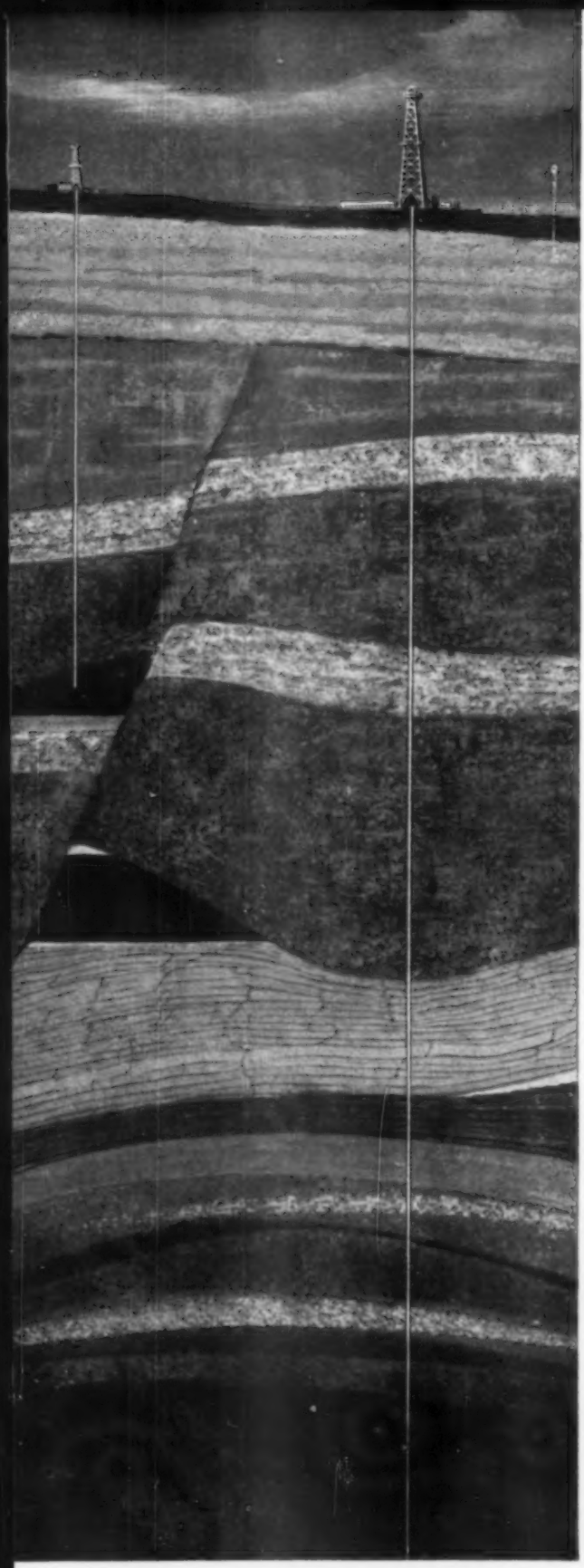
The most widely used indicator of a mud's filtration properties is its water loss as determined by the standard test described in the API Code 29. This is a static filter press test using a standard filter paper of specified mesh. The initial surge or spurt, which occurs before the mud solids bridge and begin building a filter cake, is generally not considered and the corrected 30 minute water loss is taken as the basic measurement. This is shown as V_c in Fig. 2. While this procedure may be satisfactory for mud control purposes, it does not tell the complete story insofar as formation damage is concerned.

Beeson and Wright[5] studied the filtration behavior of numerous muds against sands and filter papers of varying permeability. Their results indicated that considerable solid invasion occurred and that an internal filter cake was formed in the sand. The factors governing the entry of mud filtrate and solids into a particular sand were the pore size distribution of the sand, the particle size distribution of the mud solids, and the plastering ability of the mud. The standard API test provides data on the latter factor only. Beeson and Wright also suggested that the generally disregarded initial surge was indicative of the invasion which occurred prior to bridging. The addition of sized particles was effective in reducing the surge loss.

Ferguson and Klotz[8] have shown that downhole filtration must be considered as three separate phenomena, namely: Beneath bit, dynamic, and static filtration. No appreciable filter cake can form on the surface beneath the bit; however, experiments showed that pore plugging occurred some distance ahead of the bit. This is in agreement with the internal bridging proposed earlier. Dynamic filtration pertains to the borehole condition above the bit while mud is circulating. The rate of fluid loss is higher than the static rate during this period and eventually reaches a constant value when the filter cake reaches its maximum thickness. Further cake growth is prevented by erosion of the gelatinous, low strength, outer layer by the circulating mud and drill pipe action. Static filtration occurs during periods of noncirculation.

A fundamental method of analyzing water loss data has recently been presented by Slusser, Glenn, and Huitt.[9] This procedure utilizes standard filter press data in such a manner that three distinct stages of filtration may be evaluated:

1. The initial surge period — before any appreciable cake is formed.
2. The transition period — after a filter cake is initiated but before it becomes uniform, i.e., the period during which the cake surface is irregular and has unequal pressure gradients at different points.
3. The constant pressure gradient period — filtrate vol-



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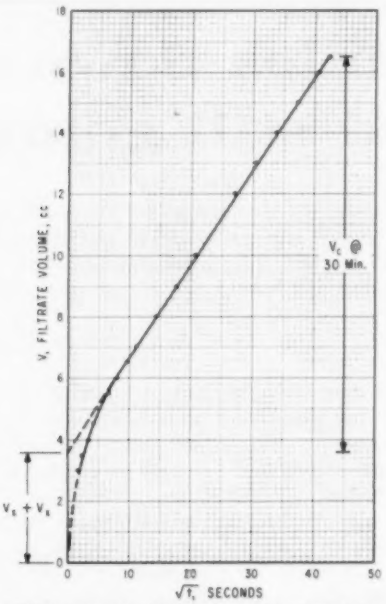

FIG. 2. Standard method of obtaining API water loss. Corrected volume, V_c, is commonly reported. $V_s + V_x$ = initial spurt or surge correction.

ume varies linearly with the square root of time.

Quantitative analysis of the loss in each stage is based on the equation:

$$t = mV^2 + nV \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where:

t = time.
V = cumulative filtrate volume.
m = a number which defines the filtration characteristics of the mud cake — increases from zero during Stage 1 to some constant value in Stage 3.
n = constant depending essentially on the permeability of the septum (filter paper or porous formation).

Rearrangement of Equation 1 is useful for plotting purposes:

$$\frac{t}{V} = mV + n \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

A plot of t/V vs V becomes linear when m becomes constant in Stage 3 of the filtration process. The surge loss, V_s, is obtained as the magnitude of V when $t/V = 0$. Careful analysis of the original data will also allow determination of the corresponding surge time, t_s. Since Stage 3 is completely governed by the permeability of the filter cake, Equation 2 may be rewritten in terms of the surge corrected volume, V' and time, t':

$$\frac{t'}{V'} = mV' \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where:

$t' = t - t_s$
$V' = V - V_s$

A plot of t'/V' vs V' becomes linear when m = constant. Hence the filtration loss during Stage 2, V_x, may be obtained as the linearly extrapolated intercept at $t'/V' = 0$.

This method is illustrated by Fig. 3 which is plotted from the data in Table 3. The standard API procedure for the same data was shown in Fig. 2. Note that the intercept in Fig. 2 is the sum $V_s + V_x$.

TABLE 1. Typical Filtration Loss Data from Standard Filter Press Test After Slusser, Glenn and Huitt.[9]

(1) V, cc	(2) t, seconds	(3) $\sqrt{t}$	(4) (2)÷(1) t/V	(5) (1)—2.6cc V', cc	(6) (2)—3.0 sec t'	(7) (6)÷(5) t'/V'
3.0	3.5	1.87	1.17	0.4	0.5	1.25
3.5	6.0	2.45	1.72	0.9	3.0	3.34
4.0	12	3.46	3.00	1.4	9.0	6.41
4.5	18	4.24	4.00	1.9	15.0	7.89
5.5	46	6.78	8.37	2.9	43	14.8
6.0	65	8.06	10.8	3.4	62	18.2
6.5	92	9.59	14.2	3.9	89	22.8
7.0	125	11.2	17.9	4.4	122	27.7
8.0	206	14.3	25.8	5.4	203	37.6
9.0	317	17.8	35.2	6.4	314	49.0
10.0	436	20.9	43.6	7.4	433	58.5
12.0	737	27.1	61.4	9.4	734	78.1
13.0	932	30.5	71.6	10.4	929	89.3
14.0	1150	33.9	82.0	11.4	1147	100
15.0	1392	37.3	93.0	12.4	1389	112
16.0	1668	40.8	104	13.4	1665	124
16.5	1800 (30 min)	42.4	109	13.9	1797	130

Note: $V_c = 16.5 - (V_x + V_s) = 12.9$cc (See Fig. 3)

This analysis allows mud filtration loss to be reported as three separate values, V_s, V_x, and V_c, which are indicative of behavior during three separate and distinct periods. The importance of this procedure lies in the observation that additives which improve Stage 3 behavior do not necessarily improve losses during other stages. The surge loss of Stage 1 is dependent on the rapidity with which the solids bridge surface and internal pore openings. A mud which contains properly sized solids for the particular sand may be expected to bridge more quickly and efficiently than one which is deficient in some critical sizes. This is substantiated by Fig. 4 which shows the difference in surge loss when various sized particles were added. Also note the percent permeability recovery.

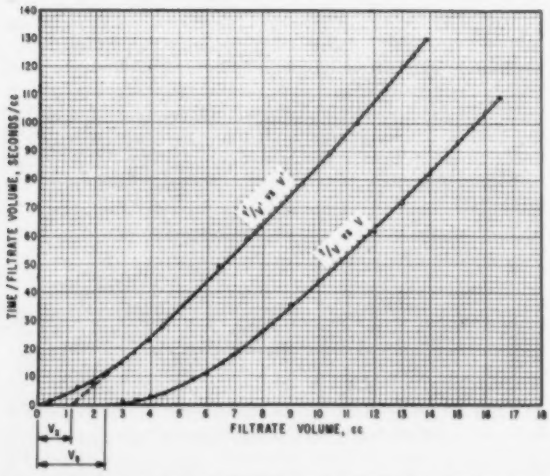

FIG. 3. Method of plotting filtration data based on Equations 1, 2 and 3. V_s, V_x, and V_c are obtained as shown. After Slusser, Glenn, and Huitt[9] courtesy AIME.

Selecting Mud for Minimum Damage

The question which immediately arises is how to predict the necessary mud particle sizes for each sand. While pore size distribution can be obtained from core analysis for a particular sample, it must also vary with each permeability in the zone as well as in all other sections up and down the hole. Consequently the logical solution is to use colloidal mud materials in proper size gradations which will quickly bridge any encountered openings. Just what this optimum size distribution should be is open to conjecture at this time. Some general relationships are, however, available in the work of Gates and Bowie.[10]

A bridge may be initiated when two large particles start into an opening at the same time and lodge against each other. Other smaller particles may then bridge the openings between the larger, previously bridged particles. If the proper particle sizes are present this process may continue until the openings become too small for any contained solid to penetrate. It is at this time that only the filtrate flows

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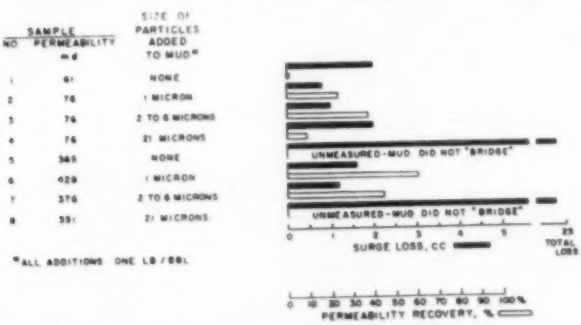

FIG. 4. Dependence of surge loss on mud particle sizes. After Slusser, Glenn, and Huitt[9] courtesy AIME.

through the filter cake. Theoretically, if enough successively smaller particles were present, the voids in the filter cake could become so small that even water molecules could not pass.

Lost circulation problems are analogous to those of filtration except that the scale is larger. Here the initial surge may often be measured in thousands of barrels. A common solution to lost circulation is the addition of properly sized granular materials which can initiate bridging and allow the normal mud solids to wall the hole. Considerable reference to proper or optimum particle size distribution for efficient bridging is also found in lost circulation literature. However, as is the case in filtration studies, no precise definition is available. Those desiring a further study of the bridging phenomena should read the work of Coberly.[11]

It should also be mentioned that results obtained at laboratory conditions are not necessarily indicative of a mud's bottom-hole filtration behavior. Schremp and Johnson[12] have observed that some premium muds may have poorer filtration characteristics at high temperature and pressure than some cheaper, lower quality muds. They conclude that muds should be tested at the conditions of use.

While this section has dealt primarily with drilling fluid contamination, the principles involved are applicable to any fluid. Cement slurries and stimulation fluids may be subjected to the same appraisal where applicable. Post completional problems such as sand face deposits of scales and/or solid hydrocarbons have not been discussed but are a well known source of productivity impairment in many areas.

PREVENTION OF FORMATION DAMAGE

The discussion of causes might also serve as a coverage of preventive measures, since the obvious prevention is removal of the cause. It might be well, however, to re-emphasize certain practical measures which may be exercised. Table 2 attempts to list the main points previously discussed along with practical preventive measures. Considerable overlapping occurs both in appraisal and prevention methods.

TABLE 2. Summary of Methods for Appraising and Preventing Formation Damage.

Damage Effects	Appraisal Methods	Practical Preventive Measures
1. Foreign Fluid Invasion (a) clay swelling (b) emulsification and "water-blocking"	(1) Special contamination and flow tests on core samples to determine compatibility of fluids involved	(1) Use of additives which will reduce filtration losses
(c) precipitation of solids	(2) 3-stage filtration test; based on Carman equation	(2) Reduce pressure differential against formation to lowest safe value
	(3) API test which includes initial correction, $V_S + V_X$	(3) Air and/or gas drilling may eliminate the problem in areas where applicable
(d) rock alteration, movement of interstitial fines	(4) Standard API test	(4) Use fluids which are compatible with formation and its contents if possible, i.e., lease crude, formation water, saline or oil base muds
(e) reduction in relative permeability due to introduction of third phase	(5) Conduct the above at temperature and pressures involved	(5) Minimize exposure time as much as possible
		(6) Use perforating fluid which does not plug or damage the exposed formation since the perforation may penetrate beyond worst of damage zone
2. Foreign Solid Invasion (a) size reduction or plugging of internal pores by intruding solids	(1) Analysis of initial surge filtration data from filter press tests	(1) Addition of properly sized colloidal solids which rapidly form an efficient bridge
(b) increased interstitial water content and consequent reduction in oil or gas permeability	(2) Actual surge data against core sample of rock in question*	Also items (2), (3), (5), (6) above

*Data by Krueger and Vogel[6] indicated that the initial surge was not particularly important with respect to solid invasion in their tests. Time of exposure was the principal factor.

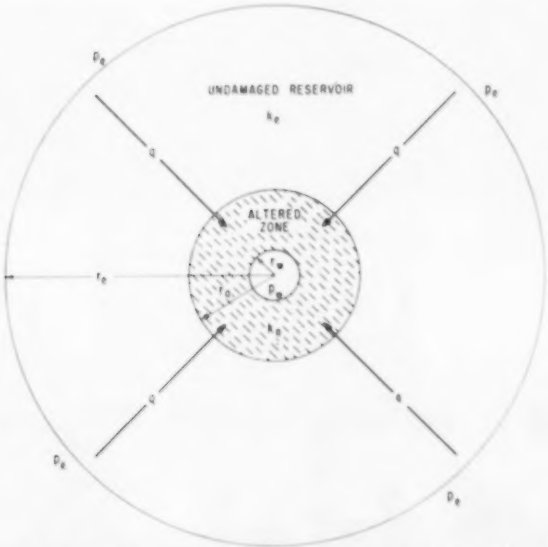

FIG. 5. Idealized sketch of drainage area around a well. Reservoir permeability = k_e, altered zone = k_s. Flow rate, q, at a given drawdown, $P_e - P_w$ depends on k_s and r_s/r_w as well as k_e and r_e/r_w.

Practically speaking, the cost of the preventive measures should not exceed the benefits obtained. Stimulation techniques are successful in overcoming formation damage effects in most cases. It is worthwhile to avoid stimulation if productivity is satisfactory without it; however, the cost of the preventive measures must be balanced against the cost and possible results of stimulation. This is not to say that both preventive measures and stimulation may not be desirable in many instances but rather that each situation requires a separate economic analysis. Formation damage is of extreme importance in some cases and of little consequence in others. Some formation damage will almost always occur during completion regardless of the preventive measures applied.

QUANTITATIVE EVALUATION AND CURE OF FORMATION DAMAGE

A well which swabs dry on completion obviously requires stimulation before commercial productivity can be obtained. There are, however, other cases in which the need, or lack of need, is not so apparent. In these latter wells it is advantageous to have some means of determining both the advisability of stimulating and the possible results which may be obtained. Such analyses require a quantitative com-

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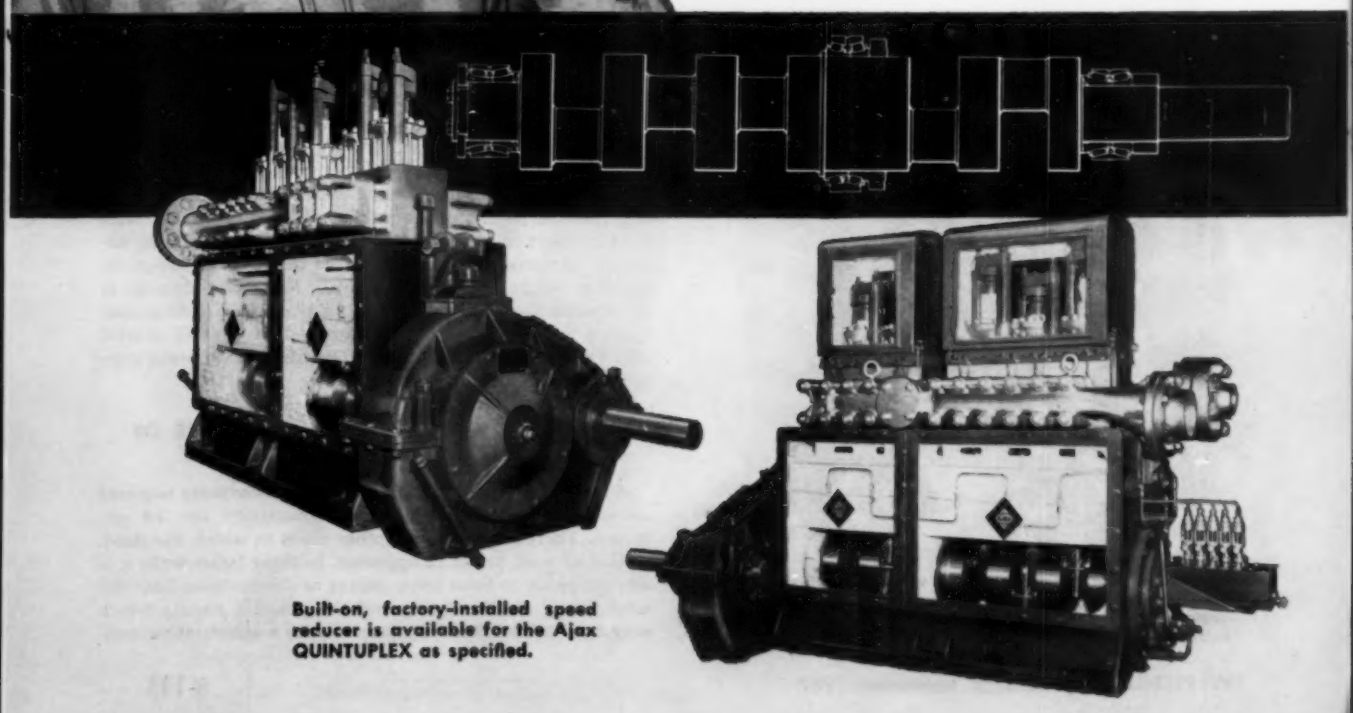

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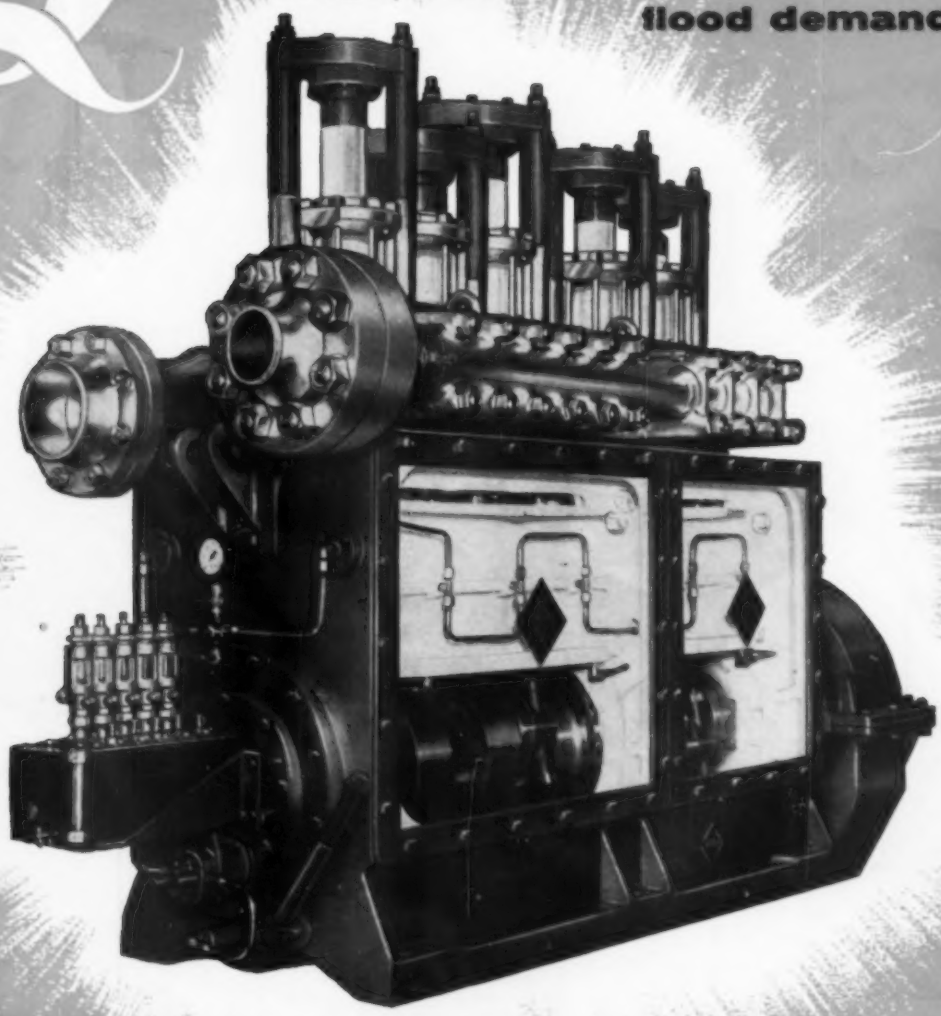

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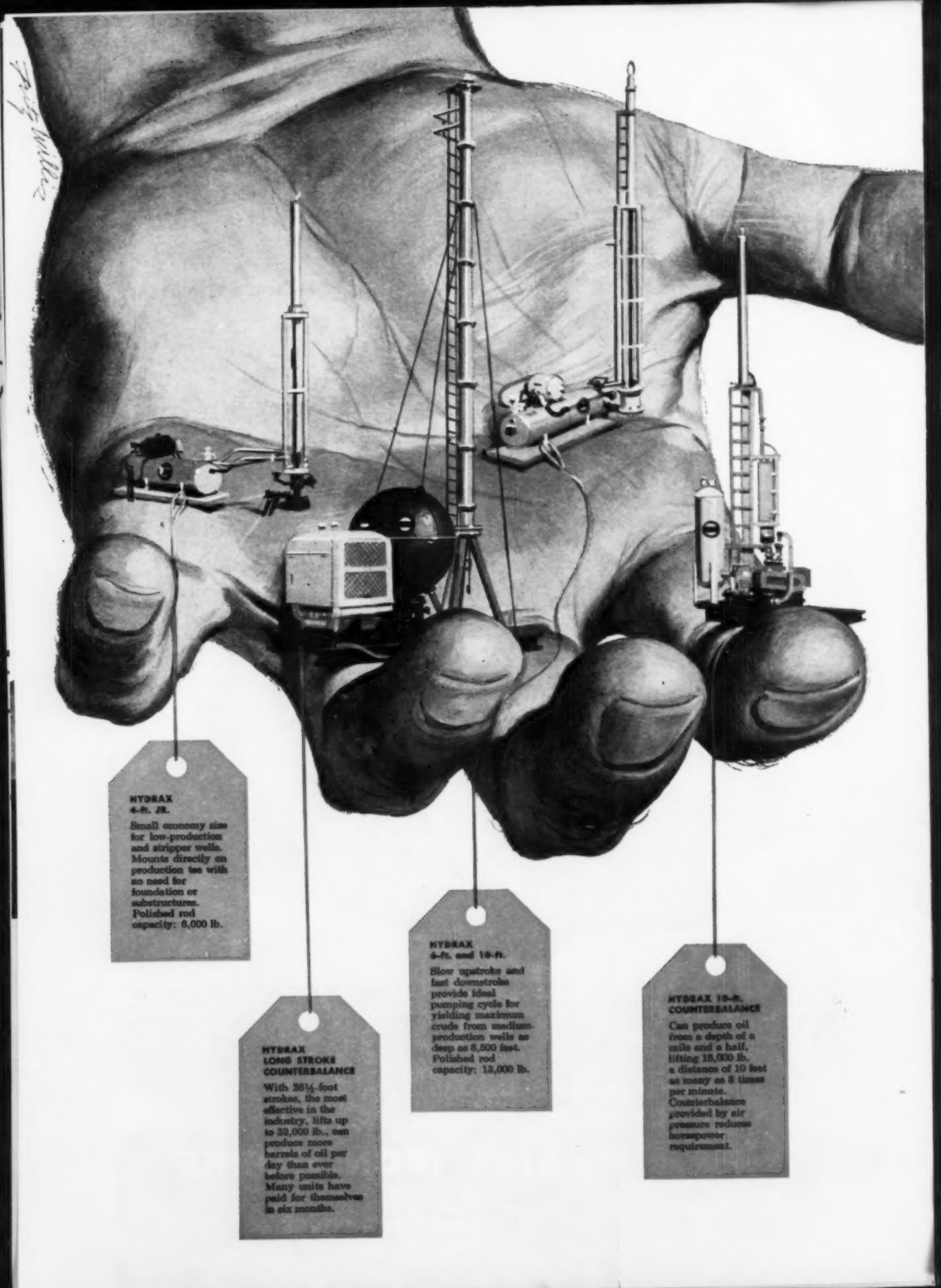
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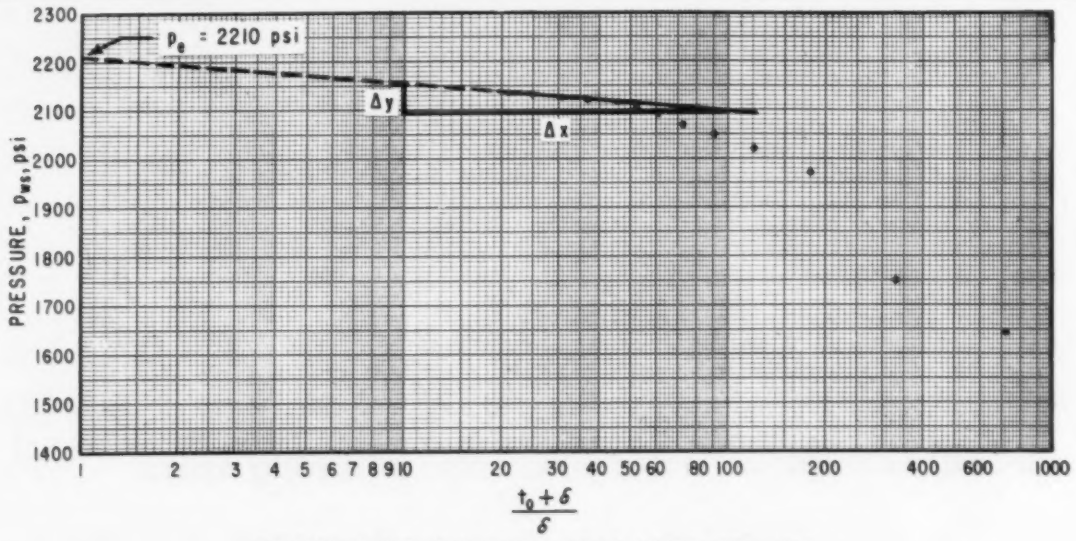

FIG. 6. Shut-in bottom-hole pressure vs log $t_o + \delta / \delta$ Data of Example 1.

parison of the current productivity (or permeability) with what it would be if no damage were present. This is to say that the skin effect must be evaluated.

One method for evaluating formation damage compares the actual productivity or permeability with that computed from core analysis data.[13] More recently pressure buildup and productivity index (PI) data have been used for analysis purposes. It is this latter method which will be discussed here. While commonly applied to the evaluation of completion effectiveness, this technique may be used at any time during the life of a well.

A rigorous treatment of pressure build-up mechanics is rather complicated and requires mathematical techniques which are beyond the training of most engineers. Numerous references are available which treat various phases of the subject; however, the works of Horner[14]; Miller, Dyes and Hutchinson[15]; van Everdingen[1]; Hurst[2]; Gladfelter, Tracy, and Wilsey,[16] and Arps[17] have been particularly instrumental in either defining the basic problem or developing practical means of solving it. In addition to these, please refer to Perrine's[18] summary of topic.

Basic Equations Evaluate Damage

The basic data required for the pressure build-up method of productivity evaluation are:

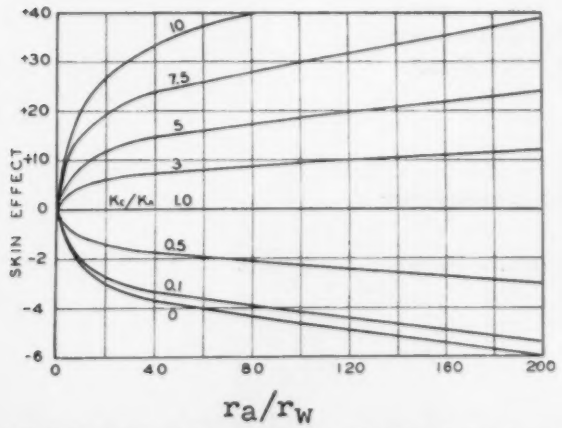

FIG. 7. Magnitude of the skin effect as a function of altered zone permeability, k_a, and radius, r_a. After Hawkins[19] courtesy AIME.

1. Steady-state flow test data — PI test.
2. Unsteady-state test data — the pressure vs time behavior of a well after shut-in, i.e., its pressure buildup behavior.
3. The well's previous production history — cumulative production and last stabilized flow rate.

Fig. 5 shows the nomenclature and general well condition to which the following equations pertain. **For steady-state conditions the average effective oil permeability** which governs the flow rate may be expressed from Darcy's Law as:

$$\bar{k}_o = \frac{B_o\, q_o\, \mu_o \log r_e/r_w}{3.07\, h\,(p_e - p_w)} = \frac{J\, \mu_o \log r_e/r_w}{3.07\, h} \quad . \quad . \quad (4)$$

where:

$\bar{k}_o$ = average effective permeability to oil, darcys.
B_o = oil formation volume factor, reservoir oil volume/tank oil volume.
q_o = tank oil flow rate, bbl/day.
μ_o = reservoir oil viscosity, cp.
r_e, r_w = drainage and wellbore radii, respectively, any consistent units.
log = base 10.
h = net pay section thickness, ft.
p_e, p_w = external drainage boundary and wellbore pressures.

$J = \frac{B_o\, q_o}{p_e - p_w}$ = productivity index, bbl reservoir oil/day/psi.

Similarly for an ideal gas:

$$\bar{k}_g = \frac{q_g\, \mu_g\, T \log r_e/r_w}{0.306\, h\,(p_e^2 - p_w^2)} \quad . \quad . \quad . \quad . \quad (5)$$

where:

$\bar{k}_g$ = average effective permeability to gas, darcys.
q_g = gas production rate, Mcf/day at 14.7 psia, 60 F.
μ_g = gas viscosity at flow conditions, cp.
T = reservoir temperature, °Rankine.

A simplified equation for expressing bottom-hole pressure as a function of shut-in time is:

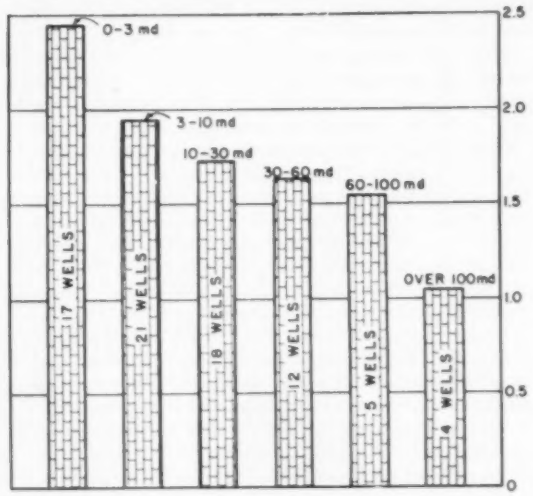

FIG. 8. Productivity ratio vs permeability of stimulated sand wells courtesy API.[20]

$$p_w = p_e - \frac{162.5\, q_o\, \mu_o\, B_o}{k_o\, h} \log \frac{t_o + \delta}{\delta} \quad . \quad . \quad (6)$$

where:

t_o = total producing life of the well.

δ = shut-in time, same units as t_o.

q_o = stabilized tank oil production rate prior to shut-in, bbl/day.

For older wells which have produced at various rates during their life, a corrected time, t_c, must be substituted for t_o.

$$t_c = \frac{N_p}{q_o} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where:

N_p = cumulative oil production from the well.

q_o = last stabilized oil flow rate.

Equation 6 is from the work of Horner[14] and is based on the assumption that the reservoir is of infinite extent. This assumption is of considerable importance when the equation is to be used for determination of p_e and the original paper should be consulted. Equation 6 states that a plot of p_w vs $\log \frac{t_o + \delta}{\delta}$ is linear and of slope, m:

$$m = -\frac{0.163\, q_o\, \mu_o\, B_o}{k_o\, h} \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This is valid when the effects of after production become negligible. After production refers to the fluids which continue to enter the well bore after the well is shut-in. This factor places a considerable restriction on the equation's use since the after production period may be quite long, particularly for wells of low productivity and those which have a large storage space available in the casing (no tubing packers).

Consider however that a sufficiently long shut-in has occurred allowing the linear behavior to be obtained. The slope may then be taken and if fluid properties μ_o, B_o, and the section thickness, h, are known; the effective oil permeabilty, k_o, may be computed from:

$$k_o = \frac{-0.163\, q_o\, \mu_o\, B_o}{m\, h} \quad . \quad . \quad . \quad . \quad (9)$$

The permeability, k_o, is the unaltered effective oil permeability of the reservoir beyond the damaged zone. This is true since the damage zone radius is quite small as compared to the drainage radius. Therefore any transient effects in this zone are of short duration and may be neglected.[1,2]

Computation of k_o is not necessary to the evaluation of formation damage. The ratio of the actual average permeability, $\bar{k}_o$, to the unaltered permeability, k_o, may be used, thereby eliminating the necessity of fluid property knowledge:

$$PR = \frac{\bar{k}_o}{k_o} = \frac{-2\, m \log r_e/r_w}{p_e - p_w} \text{ from Equation 4 and 9}$$

. . . . . (10)

where:

PR = Productivity Ratio.

The following example will serve to illustrate these calculations.

Example 1.

Given the following data on a newly completed well, compute its productivity ratio.

(1) Shut-in time, δ hrs	Buildup Data (2) Shut-in pressure, p_{ws}	(3) $\frac{t_o+\delta}{\delta}$	Flow Test Data
0.5	1480	1441	q_O = 120 bbl/day
1	1645	721	h = 20 ft
2	1750	361	p_{wf} = 1250 psi (flowing)
4	1970	181	r_e = 700 ft (taken as half the distance to adjacent wells)
6	2020	121	r_w = 0.67 ft
8	2050	91	
10	2070	73	
12	2090	61	
14	2105	52.3	Fluid Properties
16	2115	46	μ_O = 5.0 cp
20	2120	37	B_O = 1.15
24	2125	31	
30	2129	25	
36	2134	21	

N_p = 3600 bbl, cumulative production.
t_O = 30 days (720 hr) producing life.

Fig. 6 is the prescribed plot of p_{ws} vs $\log \frac{t_o + \delta}{\delta}$. The last five points exhibit linearity and allow extrapolation to $\frac{t_o + \delta}{\delta} = 1$ or $\log \frac{t_o + \delta}{\delta} = 0$ which is the value when δ becomes infinite. The pressure intercept may be taken as the final shut-in or boundary pressure, p_e, as shown on the plot. The slope is conveniently calculated over an abscissa increment of one cycle as indicated.

$$m = \frac{\Delta y}{\Delta x} = \frac{2153 - 2092}{\log (10) - \log (100)} = \frac{61}{-1} = -61$$

Therefore applying Equation 10:

$$PR = \frac{(-2)\,(-61) \log \frac{700}{0.67}}{2210 - 1250} = 0.38$$

Since $0.38 < 1$, a considerable damaged zone exists.

For further illustration $\bar{k}_o$ and k_o could have been computed from Equation 4 and 9:

$$\bar{k}_o = \frac{(1.15)\,(120)\,(5)\,(3.02)}{(3.07)\,(20)\,(960)} = 0.035 \text{ darcys or } 35 \text{ md}$$

$$k_o = -\frac{(0.163)\,(120)\,(5)\,(1.15)}{(-61)\,(20)} = 0.092 \text{ darcys or } 92 \text{ md}$$

and

$$\frac{\bar{k}_o}{k_o} = \frac{35}{92} = 0.38 \text{ as before}$$

Example 1 was a rather ideal case in that a number of complicating factors did not exist. Simple extrapolation for

p_e may not always be satisfactory and Horner's paper should be consulted for possible corrections. Also the after production effects vanished rather quickly as shown by the linearity after 14 hr shut-in time. Data in which the after production effect does not disappear within practical time limits require further manipulation. Reference 16 presents a practical means of handling this problem and contains a clear, step by step example.

Although the theory of pressure buildup analysis was based on a liquid saturated condition, the method has been successfully applied to gas wells by using Equation 11.

$$PR = \frac{4\,m\,p \log r_e/r_w}{p_e^2 - p_w^2} \text{ (for gas)} \quad . \quad . \quad (11)$$

where:

p = average reservoir pressure, psia

As shown by Hawkins,[19] the skin effect, S, may be computed from Equation 12:

$$S = 2.3\left(\frac{\log r_e/r_w}{PR} - \log r_e/r_w\right) \quad . \quad . \quad (12)$$

where:

S = skin effect.

note: (+) values indicate a permeability restriction in the altered zone,
(−) values indicate permeability improvement.

Therefore for the well of Example 1:

$$S = 2.3\left(\frac{3.02}{0.38} - 3.02\right) = 11$$

As was mentioned previously the degree of damage depends on both the altered permeability and the depth of invasion. This is illustrated by Fig. 7. A skin effect of 11 could be due to any combination of r_a and k_e/k_a values which lie on the line, S = 11, as shown.

Significance and Practical Implications

API Bulletin D6 contains a large amount of statistical data on typical PR and S values before and after stimulation.[20] These data may be used to predict the general results of stimulation treatments under various conditions. Productivity ratios of sand wells after stimulation averaged near two although considerable variation with reservoir permeability was noted (see Fig. 8). Other observations of sand well behavior were:

1. Treatment through perforations gave higher PR's than open hole treatments — averaging 2.2 for 44 perforated vs 1.4 for 31 open-hole completions.

2. The observed PR's increased with the size of stimulation treatment — 1.8 for 32 wells treated with 2000 gal or less vs 2.2 for 13 wells having 5 to 10,000 gal fracture treatments.

Limestone wells studied did not exhibit the degree of damage which was noted in many sand wells. This does not mean that limestone wells cannot be damaged. Productivity ratios of 39 lime wells averaged near 2.5 after treatment.

Suppose the well of Example 1 were fractured which increased the productivity to PR = 2. The flow rate would be increased by the factor $\frac{2.0}{0.38}$ or 525 percent. It is apparent, however, that further improvement would be so striking and probably could be obtained only by deeply penetrating, high-volume treatments. Hence the economic feasibility of stimulation decreases as the PR increases.

While not perfect the pressure buildup technique does furnish the most quantitative evaluation of formation damage which is currently obtainable. This discussion has dealt only with the elementary principles and procedures involved and should be considered only as a starting point for a complete study. Proper application of pressure buildup data will distinguish satisfactory candidates for treatment from those which will probably not respond. In this regard a factor which has not been emphasized, but which is of considerable importance in older wells, is the magnitude of the boundary or static pressure, p_e. Obviously if pressure is depleted, productivity is nil regardless of the PR.

Thus, the cure of formation damage is accomplished by stimulation. Whether this best involves fracturing, acidizing, shooting or combinations of these and other methods, depends on the formation and the choice of the operator. Careful analysis of early field wells will allow more efficient methods to be applied to subsequent completions. Large treatments, small treatments, or no treatment may result in the most economic operation. Proper selection of drilling and completion fluids may also be determined for a given formation. Premium drilling fluids are justified on a formation damage basis only if their use results in sufficient completion improvement to warrant the additional cost. After all it is the factual economic analysis and not the scientific nicety which should govern the actions taken.

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57-101

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(Continued from Page B-96)

is a particle type tracer. It has a disadvantage in that it is difficult to obtain an even distribution of the particles in the cement. Although the cement top will be shown, the effective top cannot be determined as accurately as when water-soluble CO-6 is used. However, the CT-6 particle type tracer has an advantage in those areas where cement is being lost to the formation because the particles plate out on the formation taking cement and the tracer log will show abnormally large radioactivity opposite these zones.

Amount of tracer added to cement. Sufficient tracer material is added to the cement slurry so that the resulting log will be about 10 times normal. The actual tracer log is then run at a sensitivity of 1/10 normal. On the log, the effect of natural gamma rays is very small and for all practical purposes the tracer log can be interpreted as if all the deflection is caused by the radioactive material added to the cement.

Effect of Hole Diameter

Deflections of the cement tracer log have a logarithmic relationship with hole diameter. Fig. 1 and 2 are laboratory-prepared diagrams showing this relationship.

Opposite sand or wherever the hole size is small, the measurement is dependent on the eccentricity of the pipe in the hole. See Fig. 3. As hole size increases, eccentricity within the hole becomes of lesser importance.

Fig. 5 shows an idealized log to

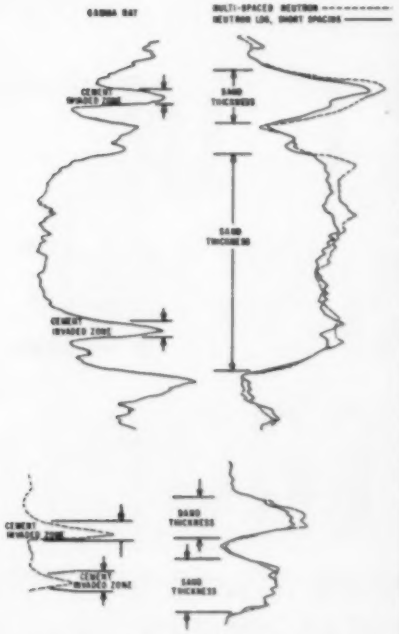

FIG. 4. **Cement invasion** can be detected by using the CT-6 particle tracers as shown on the gamma ray-neutron log above.

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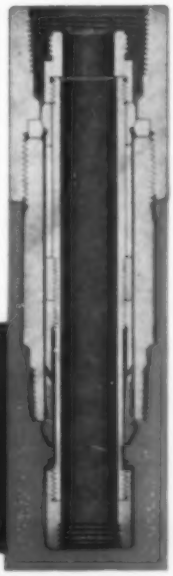
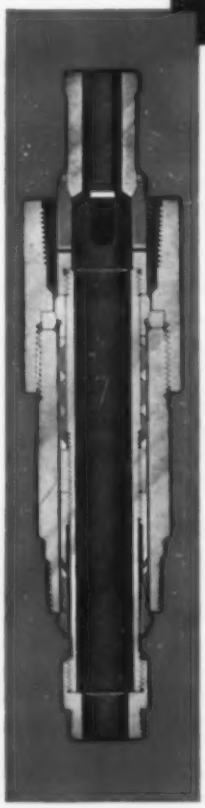


Undersize rings can also be furnished to allow pumps to be run through a Permanent Completion "S" Nipple and seated in the pump shoe.



If at any time the Stainless Sealing Ring Seat, which is part of the Tubing Assembly, should become damaged or leak, an effective seal can be obtained without pulling tubing. The Rod Assembly is engineered and designed so that by replacing the Spacer Ring on the Hold-Down Lock Body with three Ring Type Seating Cups, the seal is transferred to the Seat Support Nipple with the Sealing Ring and Sealing Ring Seat serving as a No-Go ring and supporting the load.

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illustrate the interpretation of a cement tracer log. It is assumed that the tracer is distributed evenly throughout the cement column.

Cement top is defined as the highest point reached by the cement in the well. This point is shown on a tracer log as the highest point reached by the tracer material. Effective cement top is defined as the point when the casing is firmly bonded to the formation. On the tracer log this point cannot always be picked with absolute accuracy. The log often shows a zone of diminishing radioactivity and the effective cement top is within this zone.

Usually, in areas where there has been appreciable caving in the shales, the effective cement top can be accurately and readily determined as shown on Fig. 3. In areas where the hole is to gage, it is more difficult to pick the effective top although the cement top will be clearly shown. Because of possible eccentricity of the pipe, a greater tolerance must be allowed in picking the effective cement top.

CEMENT TOP INTERPRETATION

With water-soluble CO-6. The water soluble tracer materials are the easiest to use, and produce a tracer log which is readily interpreted as shown in Fig. 3.

CO-6 tracer is normally added to the cement uniformly by mixing a given quantity with water in the measuring tanks or by metering it into the cement slurry at a constant rate. When the tracer material is evenly distributed throughout the cement column, the top is clearly marked, the channeling of the cement is indicated and thief zones are identified.

The Author

Russell G. Norelius is chief logging engineer of Petro-Tech Service C. A., Caracas, Venezuela. He received his BA degree in electrical engineering from the University of Minnesota in 1934. Russ joined Lane-Wells Company in March of 1939 as an electrolog trainee at Los Angeles. Upon his return from the service in November 1945, he was appointed Pacific Coast division operating engineer. In 1952 he transferred to Petro-Tech as a logging engineer. Norelius has authored a number of articles on logging including "Electrical Logging in Oil Base Drilling Fluid," and "Interpretation of Oil Base Electrologs."

With particle CT-6 tracer. The interpretation of a tracer log for cement top, when using particle tracer CT-6, follows the same pattern as for logs using CO-6. There will tend to be some differences because the specific gravity of the particles and hand injection methods used do not facilitate a uniform distribution of the tracer in the slurry. The cement top will be shown accurately and clearly, but the effective cement top will be indicated less distinctly than when using the water soluble tracer CO-6.

Sands Taking Cement

Water-soluble CO-6 tracer. Fig. 6 illustrates a sand which has taken cement. Assuming a porosity of 18 percent, there is roughly ⅙ as much cement in the pore space of a sand as there is opposite an enlarged bore hole. Therefore, radioactivity values of the invaded sand should be no greater than ⅙ of the radioactive values opposite an enlarged bore hole. This same effect could be produced by the presence of a radioactive sand. However, in Venezuela, excepting for radioactivity due to siltness of a sand, there are few if any sands that show any appreciable amount of radioactivity.

To detect cement being lost in a sand, the tracer material should be distributed uniformly throughout the

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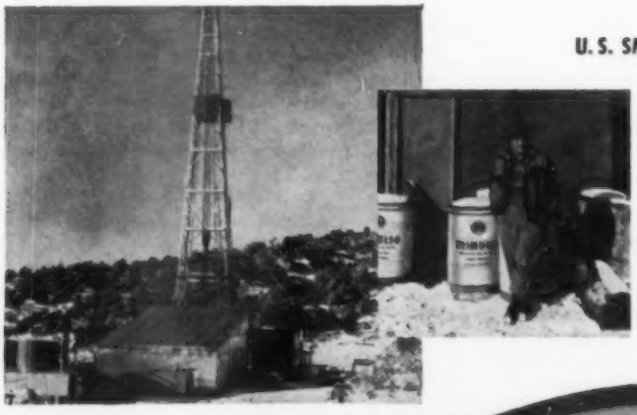

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trouble-free hole in Federal MacIntyre No. 1, near Craig, Moffat County, Colorado, being drilled by Signal Drilling Company with their Rig No. 2. They used TRIMULSO emulsion from 3000 feet. Numerous drill stem tests were run, and E. F. "Buck" Lain, toolpusher, says he had "no hole trouble." The photograph was taken at 6500 feet, and projected depth of well is below 11,000 feet.

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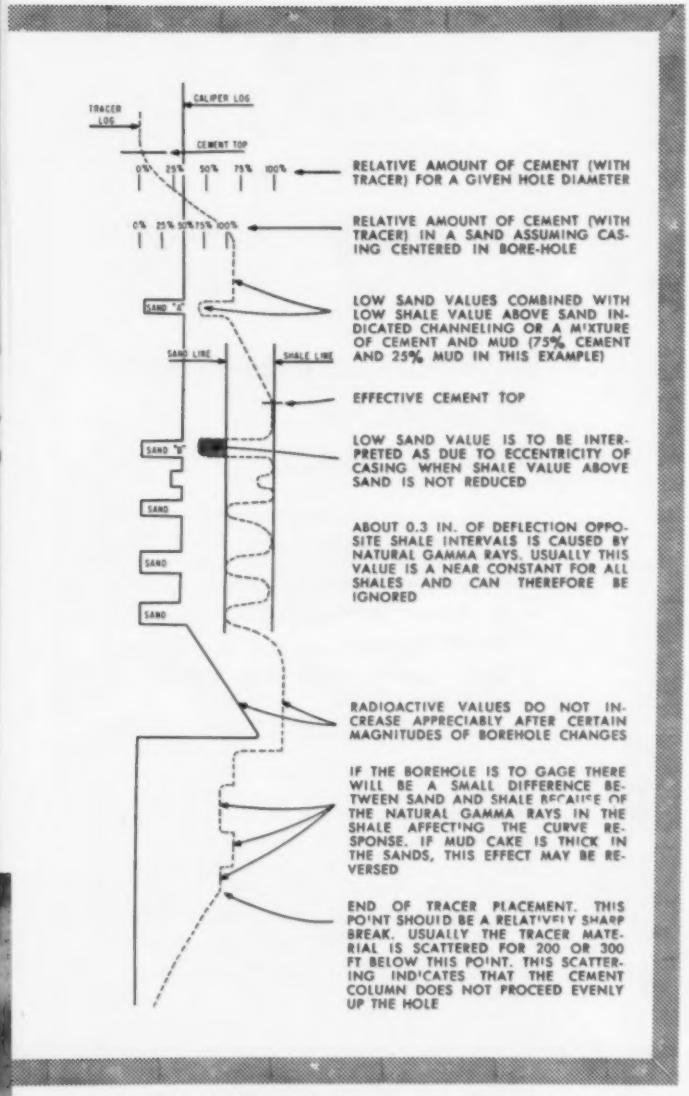
TRACER LOG
CALIPER LOG
CEMENT TOP
0% 25% 50% 75% 100%
RELATIVE AMOUNT OF CEMENT (WITH TRACER) FOR A GIVEN HOLE DIAMETER
0% 25% 50% 75% 100%
RELATIVE AMOUNT OF CEMENT (WITH TRACER) IN A SAND ASSUMING CASING CENTERED IN BORE-HOLE
SAND "A"
LOW SAND VALUES COMBINED WITH LOW SHALE VALUE ABOVE SAND INDICATED CHANNELING OR A MIXTURE OF CEMENT AND MUD (75% CEMENT AND 25% MUD IN THIS EXAMPLE)
SAND LINE
SHALE LINE
EFFECTIVE CEMENT TOP
SAND "B"
LOW SAND VALUE IS TO BE INTERPRETED AS DUE TO ECCENTRICITY OF CASING WHEN SHALE VALUE ABOVE SAND IS NOT REDUCED
SAND
SAND
SAND
ABOUT 0.3 IN. OF DEFLECTION OPPOSITE SHALE INTERVALS IS CAUSED BY NATURAL GAMMA RAYS. USUALLY THIS VALUE IS A NEAR CONSTANT FOR ALL SHALES AND CAN THEREFORE BE IGNORED
RADIOACTIVE VALUES DO NOT INCREASE APPRECIABLY AFTER CERTAIN MAGNITUDES OF BOREHOLE CHANGES
IF THE BOREHOLE IS TO GAGE THERE WILL BE A SMALL DIFFERENCE BETWEEN SAND AND SHALE BECAUSE OF THE NATURAL GAMMA RAYS IN THE SHALE AFFECTING THE CURVE RESPONSE. IF MUD CAKE IS THICK IN THE SANDS, THIS EFFECT MAY BE REVERSED
END OF TRACER PLACEMENT. THIS POINT SHOULD BE A RELATIVELY SHARP BREAK. USUALLY THE TRACER MATERIAL IS SCATTERED FOR 200 OR 300 FT BELOW THIS POINT. THIS SCATTERING INDICATES THAT THE CEMENT COLUMN DOES NOT PROCEED EVENLY UP THE HOLE

FIG. 5. How to interpret cement tracer radioactive log is shown in this composite hypothetical log indicating principal characteristics.

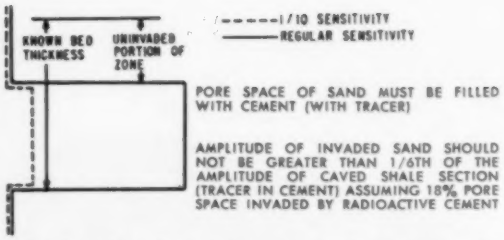
1/10 SENSITIVITY
REGULAR SENSITIVITY
KNOWN BED THICKNESS
UNINVADED PORTION OF ZONE
PORE SPACE OF SAND MUST BE FILLED WITH CEMENT (WITH TRACER)
AMPLITUDE OF INVADED SAND SHOULD NOT BE GREATER THAN 1/6TH OF THE AMPLITUDE OF CAVED SHALE SECTION (TRACER IN CEMENT) ASSUMING 18% PORE SPACE INVADED BY RADIOACTIVE CEMENT

FIG. 6. Invasion of cement into porous formations can be detected using water soluble CO-6 tracer as indicated above.

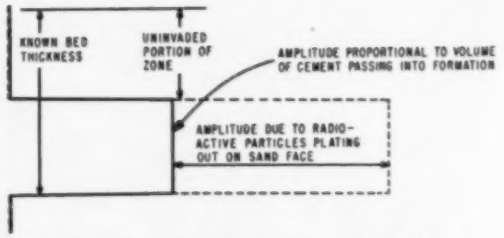
KNOWN BED THICKNESS
UNINVADED PORTION OF ZONE
AMPLITUDE PROPORTIONAL TO VOLUME OF CEMENT PASSING INTO FORMATION
AMPLITUDE DUE TO RADIOACTIVE PARTICLES PLATING OUT ON SAND FACE

FIG. 7. Cement invasion as detected by using CT-6 particle tracers which plate out on the sand face. Amplitude of regular sensitivity curve is proportional to volume of cement passing into formation.

entire column. Fig. 4 illustrates cement invasion of sands.

When it is not practical to treat the entire column, satisfactory results may often be obtained by treating the upper ⅓ of the cement. Generally, when this is done, the middle section will be contaminated to some degree by the treated cement because of turbulance set up by irregularities in the bore hole. As the slurry travels up the annulus, the bottom ⅓ will usually be uncontaminated and any sand showing a large radioactive value roughly equivalent to radioactivity of a normal shale can be regarded as having taken cement.

In an operation of this nature, the fact that a sand does not show high radioactive values, does not necessarily mean it did not take cement. With tracer in only the first ⅓ of the cement column, any breakdown of the sand after the treated cement passes will not appreciably change the radioactive value of the sand. (The radioactive values of sand, cement and displaced oil, water or mud is low.)

In order to locate a sand taking cement, its breakdown must occur while the first ⅓ of the cement is in contact. After passage of the treated slurry, there must be no more cement movement into the sand. Should this occur, the tracer will be flushed away from the face of the sand and out of range of the gamma ray device, which has a depth of measurement penetration of only a few inches.

In a well where loss of circulation has occurred or can be expected, the entire cement column should contain a homogeneous mixture of the water soluble tracer material CO-6 to be certain that the tracer log will identify all the anomalies that occur.

Sands Taking Cement

Particle CT-6 tracer. Invasion of sands with cement can more readily be identified and evaluated by using the particle tracer CT-6. The particles will tend to plate out on the sand face and resulting radioactive values recorded on the tracer log will increase with the depth of invasion of the cement into the sand. (Fig. 7.)

The most desirable method of mixing the particle tracer to the cement is to add it uniformly to the entire column. Any zones taking cement will be clearly identified as well as the cement top. If the particle tracer is added to only the first portion of the column, one thief zone might take all the cement with tracer particles added to it and then all the information pertaining to other zones or to cement tops would be lost.

Many uses in cement location. Radioactive tracer logging with oil well cementing has proved a versatile technique. Cement tops can be identified with both the water soluble and particle tracer materials. Channeling can best be identified by using water soluble CO-6 tracer uniformly distributed throughout the entire cement column. Thief zones can best be identified by using particle tracer CT-6 mixed throughout the entire cement column. Special cement location problems can be solved by tailoring the use of these types of tracer materials to the particular well condition involved. ★ ★ ★

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First John Franklin Carll Award goes to Herbert C. Otis, Sr., right, chairman of the board, Otis Engineering Corporation, Dallas, for distinguished achievement in petroleum engineering. John P. Hammond, Amerada Petroleum Corporation, Tulsa, and 1957 Society president, made the award. Photo courtesy Dresser Industries, Inc.

Petroleum Engineers Hold Biggest Meet

75 technical papers, attendance of over 3500, special awards and new SPE president highlight history-making meet

The fall meeting of the Society of Petroleum Engineers of AIME held last month in Dallas, Texas, drew a record-breaking attendance by engineers from all over the globe to hear 75 technical papers during the three-day meet. Two awards were given, and the 1958 SPE president, Basil P. Kantzer, of Union Oil Company of California, Houston, Texas, was introduced. Dr. Carey Croneis, provost of Rice Institute, Houston, was the feature speaker at the welcoming luncheon.

Technical sessions at three hotels were held simultaneously during the three-day meeting. Each session consisted of papers dealing with reservoir fluids, waterflooding, economics and management, reservoir engineering, drilling, production engineering, solvent flooding, well completions and simulation, core analysis, modified gas drive processes, production chemistry, well logging and field case histories.

Special awards. Herbert C. Otis, Sr., chairman of the board of Otis Engineering Corporation, Dallas, was the first recipient of the John Franklin Carll Award. This award, "to recognize distinguished achievement in or contributions to petroleum engineering," was a bronze plaque bearing the likeness of Carll (1828-1904), whose ideas and writings first expressed principles of petroleum engineering used today. Otis was recognized for originating the system of running pipe under pressure in oil and gas wells, thus enabling them to be completed without subjecting the formation to heavy drilling fluids.

The Cedric K. Ferguson Medal for the best technical paper of the year prepared by an AIME member under 33 years of age went to W. O. Brown of Humble Oil & Refining Company, Houston. ★ ★ ★

Basil P. Kantzer, vice president, Gulf Division, Union Oil Company of California, Houston, is the 1958 president of the Society of Petroleum Engineers of AIME.

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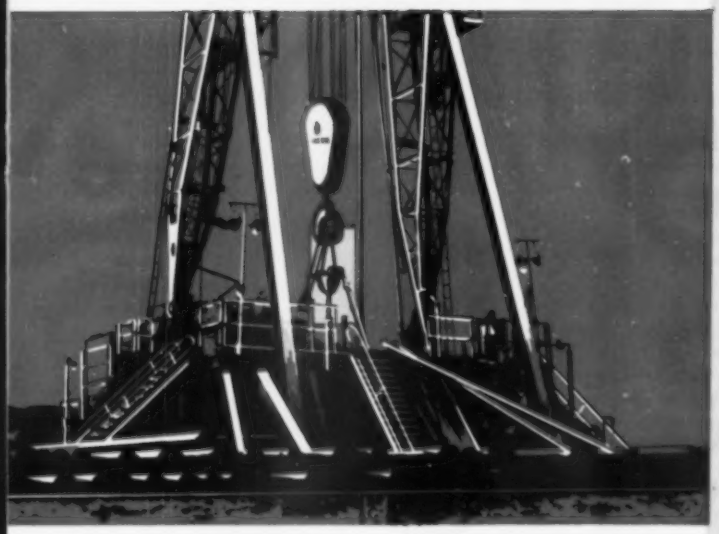

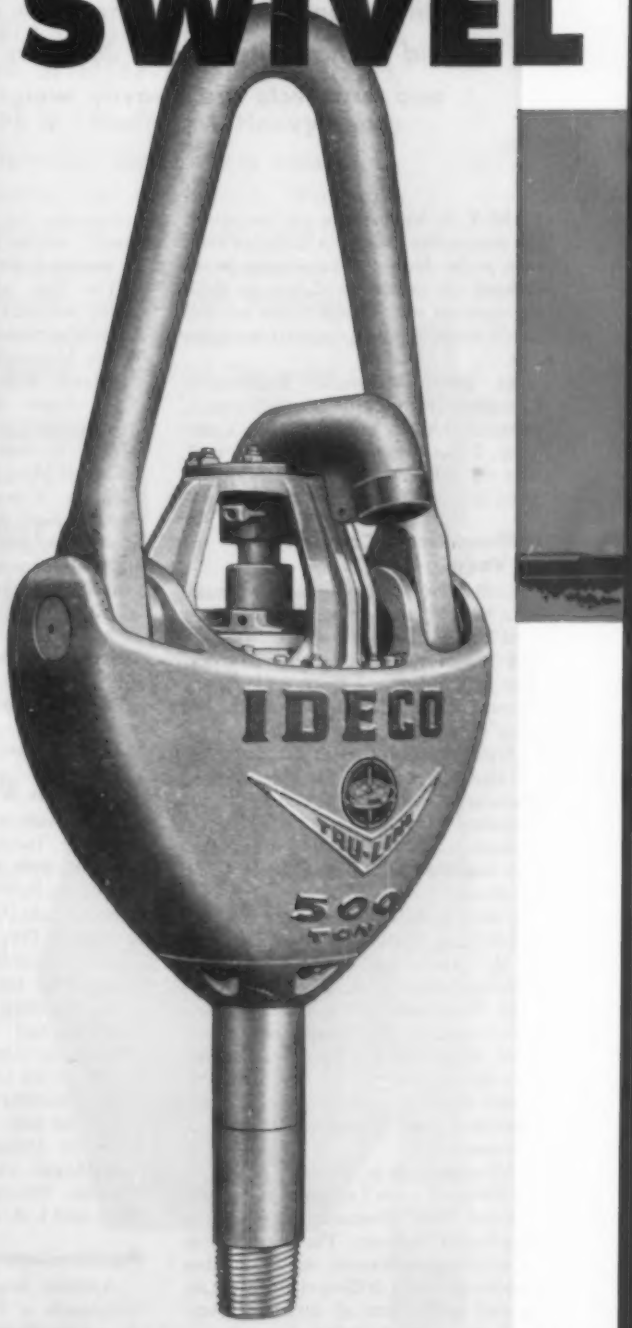

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Contract Drilling Gains Favor

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EARLY in Venezuelan oil operations the companies who went in drilled their own wells. Now the contractor is becoming an important factor in drilling operations although there are still more company rigs than contractor rigs.

In 1954, Richmond Exploration Company (Standard of California), contracted with Loffland Bros. Company, Tulsa, Oklahoma, to drill a well. The rig for this first contract job arrived in January 1946.

Loffland Bros. Company of Venezuela

Loffland since has completed more than 600 wells and nearly 4½ million ft of hole. In 1956 the company drilled 188 wells and completed 100 workover jobs in Venezuela. Since 1954 the amount of drilling by Loffland has been sharply increased both in terms of wells and footage.

Latin American headquarters are at Maracaibo, under the direction of Vice President W. F. Ogden. T. P. McCabe is manager of operations. Superintendent Donald Miller is assisted by L. H. Marts and J. D. Calloway.

Contract headquarters are on the eighth floor of Edificio Polar, Caracas. W. A. Lambert is manager for Venezuela and other S. A. countries.

In Venezuela the company maintains a modern IBM accounting department, full facilities for payroll distribution and operation, an industrial relations division, purchasing group, engineering, and full contact and contract representation.

All operations in Western Venezuela are supplied from Loffland's K-9 yard, situated nine kilometers out on the Machiques highway. The yard is able to outfit a drawworks and the other components of a drilling rig from stock, as well as perform all details of overhaul and rebuilding rigs.

The K-9 yard as well as the Loffland headquarters in Maracaibo are tied into all the Loffland rigs in Western Venezuela by radio network which greatly speeds drilling work and adds to customer services.

The five lake-drilling tenders recently put into operation are operated from Maracaibo and the two-way radio in the Maracaibo radio room crackles constantly with calls.

At Anaco are Eastern Venezuela headquarters where Bob Cunningham is superintendent and M. W. Watson and Burl Morgan are assistant superintendents. A complete yard, similar to the K-9 yard, is set up at Anaco. Radio is also the method of communication between camps and rig locations at Anaco, Maturin, and Roblecito.

In this area a trailer-mounted U-15 drawworks can complete a well and move to another location each eight days. Roblecito operations feature these trailer-mounted rigs. Slush pumps are mounted also and move cross-country behind bulldozers.

Helmerich & Payne, C. A.

This subsidiary of Helmerich & Payne, Inc., Tulsa, operates out of Caracas, with district points at Barinas and Santa Barbara. Address in Caracas is Apartado Candelaria 9266, Ave. Urdaneta 119; telephone, 55-7092.

The following rigs are operating in Venezuela: two 16,000-ft steam rigs; three National 125, 16,000-ft diesel-powered rigs, and one National 50, 8000-ft rig diesel powered.

Two of the 125 rigs are in the Barinas area. The other four rigs will be operating in the east.

W. H. Helmerich, III is president; Lee Daniel, executive vice president; Charles DeLay, general superintendent, and I. B. Allen, office manager.

Perforaciones Delta, C. A.

Another large drilling contractor in Venezuela is Perforaciones Delta, C. A., a subsidiary of Delta Drilling Company, Tyler, Texas. Head offices are in Caracas (Apartado 2735) where vice president and general manager, Clyde Johnson, is in charge. Office manager is Jim Morris.

Delta has offices at Maracaibo (Apartado 643. Cable: DELTADRIL. Telephone: 2601) where the superintendent is H. L. Shepard and the chief drilling engineer is W. W. Stevenson. Seven rigs are operating from this headquarters in Lake Maracaibo. Two others are also in the western division.

In El Tigre (Apartado 425) J. C. Coe is superintendent, and general drilling superintendent is O. B. Rylander. In this eastern division Delta has eight rigs working.*

No.	Type
Eastern	
1	Ideco H-40-D (diesel)
2	Ideco H-40-D (diesel)
3	Failing 2066
5	Emsco UBLS (steam)
6	Ideco H-40-D (diesel)
7	Ideco H-30-D (diesel)
10	Cardwell 0 (diesel)
12	Emsco J-1250 (diesel)
Western	
8	Emsco G-500 (diesel)
11	National T-12 (diesel)
13	Emsco J-1250 (diesel)
14	Emsco ECB (dsl-elec)
15	Emsco ECB (dsl-elec)
16	Emsco ECB (dsl-elec)
4	Ideco H-40-D(diesel)
9	Emsco GB-800 (diesel)

*See Rig Locator, The Petroleum Engineer, October 1957, for further details on rigs.

D & D Drilling & Construction Company, C. A.

Subsidiary drilling company of Falcon Seaboard Drilling Company in Eastern Venezuela is D & D Drilling & Construction Company, C. A., Anaco, Anzoategui. Mailing address is Apartado 4128, Puerto La Cruz, and to telephone call through Mene Grande Oil Company, at San Tome.

Vice president in charge is J. L. Hauss, Tulsa. At Anaco E. L. Walton is general manager; Ernest Neipp, office manager; Mahlon Mundy, drilling superintendent; L. E. Burt, assistant

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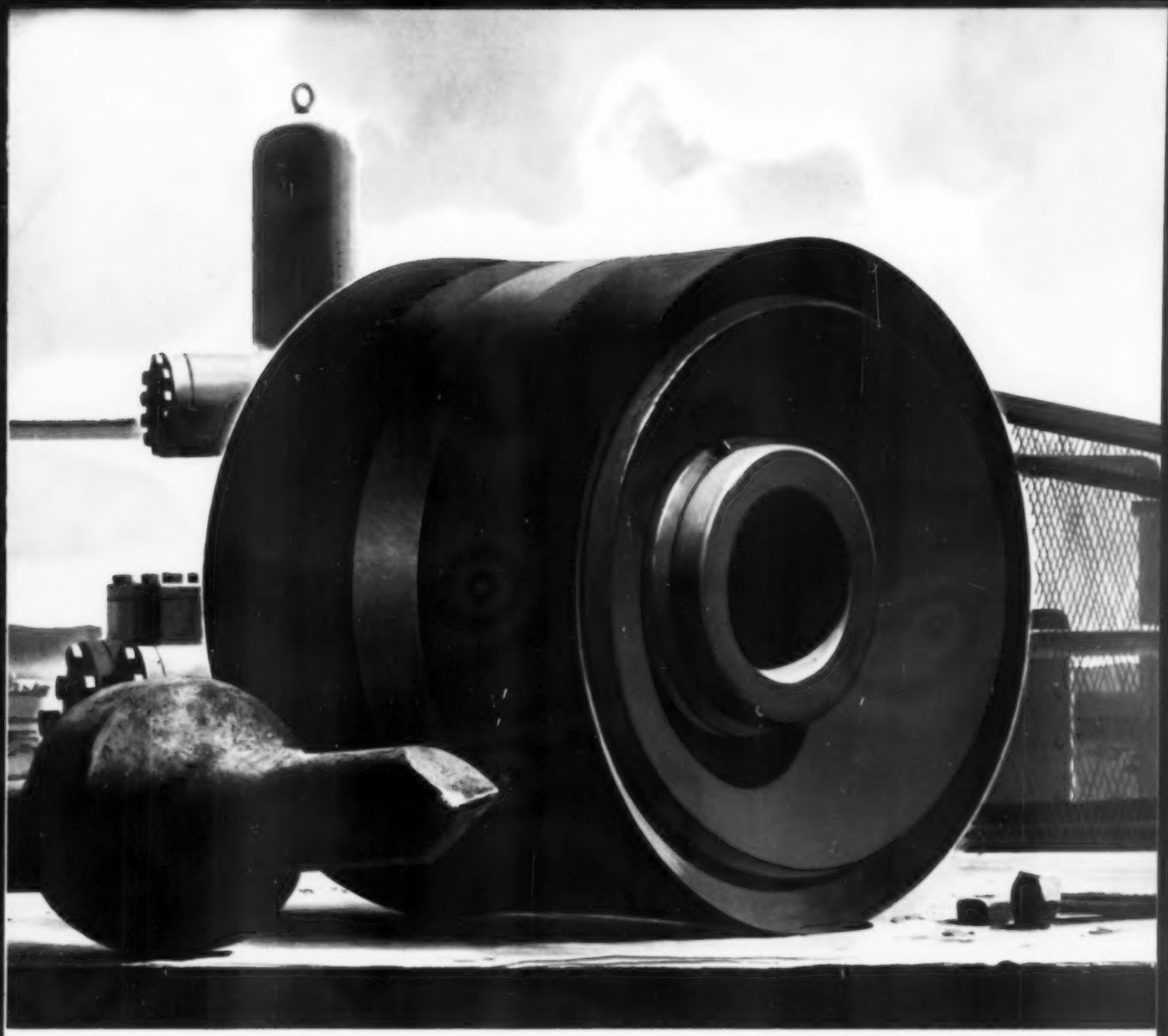
Or, if you don't require high pressures, you can get far longer service life than before.

Why? There are many good reasons! In the past ten years for example, *27 improvements*



have been incorporated into Mission Pistons.

Most of these improvements, such as advances in piston rubber compounds, can't be seen, but they mean that today's Mission Pistons are giving excellent service under jet drilling conditions that would have been considered impossible only ten years ago.

In addition to the changes actually made, Mission Engineers have conducted *371 test pump laboratory and field tests on piston rubbers alone in just the last three years.* That's an average of over 120 tests per year.

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drilling superintendent; and Roy Backus, transportation superintendent.

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4	National T-32	Drilling
5	National 75	Drilling
6	National T-32	Drilling
7	National 34-FE-10 (Steam)	Drilling
8	EMSCO ECB-10½ (Steam)	Drilling

In addition to transporting its company rigs, D & D contracts to move other rigs, do road and location work, and other dirt-moving work for other operators.

Kermac Drilling Company of Venezuela, C. A.

This is Kerr-McGee's operating company in Venezuela. Its headquarters are at Edificio Marazul, Carretera Union (Calle 84), No. 4-55, Maracaibo.

The company has two Lake Maracaibo-type drilling rigs — that is with the conventional lake-type tender and rig drawworks mounted on a separate platform structure.

Firm is under direction of Leo P. LeBron, manager of operations, and M. C. Womack as senior toolpusher, both LeBron and Womack having had considerable experience in Kerr-McGee Gulf Coast operations. The two rigs are both diesel electric Continental-Emsco. In addition to the drilling equipment there are nine 40-ft diesel-powered crewboats, two 110-ft workboats and one 700-hp tugboat, which are operating as auxiliary marine equipment.

The Offshore Company

A new Venezuelan firm has been set up by The Offshore Company, Baton Rouge, Louisiana. They have at present two Maracaibo-type drilling barges working. Headquarters are at Maracaibo in the Del Lago Hotel. Henry Snyder is superintendent and Carlos Broughton, representative.

Reading and Bates

New arrivals in Venezuela are drilling contractors Reading and Bates. First rig of this firm in the country is drilling in Barinas.

Other drilling contractors in Venezuela are Brown Drilling Company, Long Beach, California; Gulf Coast Drilling and Exploration Company, Laurel, Mississippi; American Tidelands, Inc., Houston, Texas, and Santa Fe Drilling Company, Santa Fe Springs, California.

Problems

Drilling contractors in Venezuela are subsidiaries of experienced companies in the United States. They can call on domestic operations for capable men to handle supervisory jobs.

There is a difference of opinion concerning supply of trained personnel. Most contractors agree that the future will bring shortages with increased drilling in prospect.

Contractors must hire a minimum of 75 percent Venezuelan personnel and sometimes the language barrier is a hindrance. But as one contractor said, this soon takes care of itself. A large number of people — both Venezuelans and United States newcomers have become bilingual in the oil fields.

Housing is a big problem. Contractors solve this generally by using trailers. Many of these are modern, air conditioned homes on wheels.

Drilling rigs and barges are brought from the United States but some equipment is bought from supply stores close to operations.

Larger warehouse inventories now carried by supply houses have been a great financial help to contractors. They have not had to tie up so much working capital. Several contractors mentioned this as an improvement for contract operations.

There is little doubt that the trend toward drilling contracting will continue in Venezuela as it has in the United States. Specialized work is more efficiently handled by companies devoted to that specialty. ★ ★ ★

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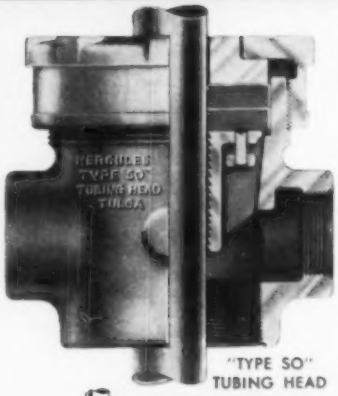

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Taxes, Labor Cited for Rising Prices

IN A NEW study of the wage, price, profit trends in manufacturing industry, the National Association of Manufacturers took sharp issue with those individuals who blame industry for rising price levels.

"The conclusion is inescapable," the study said, "that the current inflationary push is due to rising costs of labor and the continuing heavy tax burden, and not to the 'greed' of manufacturers for exorbitant profits, as some claim."

Actually, the NAM pointed out, not a single industry group "showed any improvement in its after-tax profit margin on sales between 1948 and 1956."

In fact, the study showed that every major industry group had a profit margin decline. On the average, profits as a percent of sales dropped from 4.9 percent in 1948 to 3.1 in 1956 "falling from a level characteristic of prosperity years to a level characteristic of recession years."

While profits in every branch of manufacturing have suffered from the cost-price squeeze, the NAM study noted that there is considerable range —industry by industry—in the degree.

An answer for this is found in the fact that industries vary greatly in the proportions of labor and capital that they use. "Some industries use a great deal of labor compared with the amount of capital they have invested," the study said. "These are the labor-intensive industries. Others use a great deal of capital combined with a relatively small amount of labor, and these are the capital-intensive industries. These differences can be measured in terms of number of workers per million dollars of capital invested."

The study shows that the ratios vary greatly. For example, in the clothing industry about 300 persons are employed per million dollars invested, while in the petroleum refining industry the ratio is about 13. The NAM statistics show that the industries whose profits have been hit most severely are in the labor-intensive group.

In the period covered by the study — 1948-1956 — total physical output increased by 40 percent and the increase in dollar sales was even greater, 56 percent. During that period total compensation of manufacturing employees rose 72 percent, but aggregate manufacturing profits lagged behind.

"Because total labor costs are about three and one-half times as great as before-tax profits in manufacturing," the study said, "a relatively small percentage increase in labor's dollar share, if taken from profits, will cause a substantial percentage drop in the profit figure." ★ ★ ★

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A bonus feature of the novel two-stage design is the absence of gas or fluid found in the low efficiency range. Static pressure acts on the hollow polished rod when the top traveling valve is closed and actually pulls a tension in the rod string during the downstroke, resulting in improved plunger travel, decreased load range on the rods, reduced torque on the unit gear box, and lowered horsepower requirements on the prime mover.

Don't puzzle over the problem of pumping foamy or gassy oil. Call your Oilmaster Representative and ask him about the Ratio-Compound, or write Fluid Packed Pump Co., Box 64, Los Nietos, California for literature.

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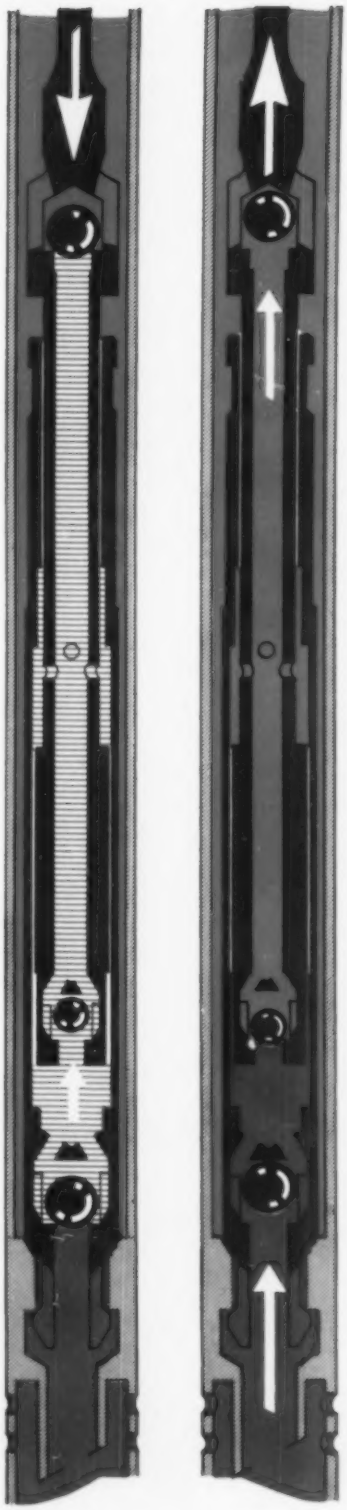
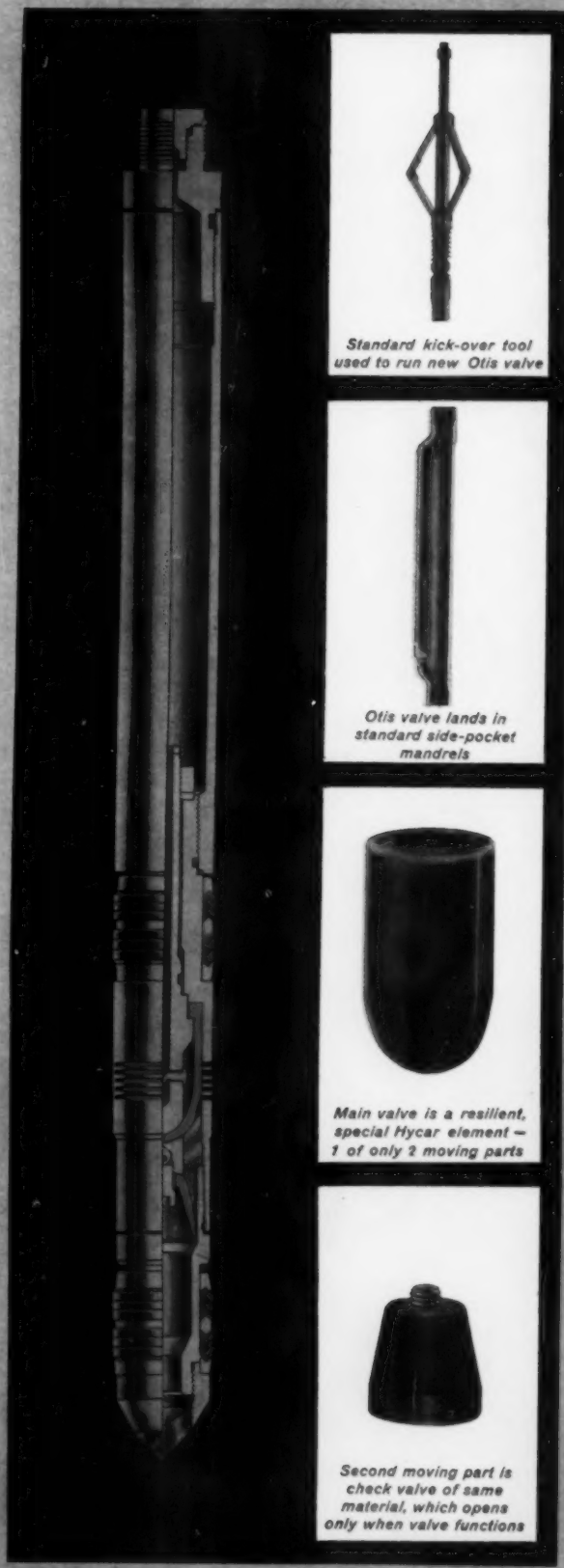


On the upstroke, fluid and gas enter the pump through the standing valve into the full area of the barrel underneath the plunger. This is the first stage chamber. At the beginning of the downstroke, the top traveling valve closes, and the gas is compressed and the fluid displaced into the second stage chamber which is the annular area between the hollow polished rod and the barrel above the plunger. On the subsequent upstroke the top traveling valve opens and the annular chamber discharges the fluid and compressed gas into the tubing.

Announcing the T



Standard kick-over tool used to run new Otis valve

Otis valve lands in standard side-pocket mandrels

Main valve is a resilient, special Hycar element — 1 of only 2 moving parts

Second moving part is check valve of same material, which opens only when valve functions

Type F Otis Retrievable Gas Lift Valve

It's New... It's Different... It's the Valve Gas Lift Men Have Been Wanting to Run for Years!

ONLY 2 MOVING PARTS... NO METAL MOVING PARTS

Imagine a tool with no valve seats to cut out... no metal bellows to fatigue ... and with a dome area sufficient to open the valve on only 10 to 15 pounds' build-up above the set pressure. And once a string of Type F Otis Valves is installed, a well can be lifted either by continuous or intermittent flow, *simply by adjustments at the wellhead. No need to run another string to convert a system — a simple solution to borderline wells* (one-third of the gas lift wells on the Gulf Coast). The new Otis retrievable valve is also

- *Completely surface-controlled . . . operated by the gas injected at the surface*
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All in all, you'll find this new valve to be the most efficient, flexible gas lift valve on the market... with many operating features not available in any other equipment. Your nearest Otis office will be glad to give you additional details, illustrated literature, and advise you on using these versatile new valves in your gas lift program without any obligation. Otis Engineering Corporation · Dallas · Branches Throughout the Oil Country.

OTIS Gas Lift

NPC Reports:

U. S. Oil Producing Capacity Reaches 9,867,000 bbl Daily

WALTER S. Hallanan, chairman of the National Petroleum Council has released the report of the Council's Committee on Petroleum Productive Capacity (1957). The report was presented to the Council by L. F. McCollum, president, Continental Oil Company, Houston, and chairman of the committee. The committee undertook its study at the request of H. W. Stewart, director, Office of Oil and Gas, United States Department of the Interior.

McCollum, in reporting the findings of the Committee stated that the United States had the capacity to produce 9,867,000 bbl daily of crude oil and 845,000 bbl daily of natural gas liquids in January 1957. He stated that the January productive capacity could not be sustained for more than a brief period without drilling additional wells.

"It is difficult to estimate with reasonable accuracy the extent of the decline in productive capacity if there were no drilling, because the industry has had no experience with such a situation. Subject to this reservation, the committee estimated a decline in the order of 7.5 percent in the first year," he said.

"Curtailment of drilling would have serious immediate effects, and no less serious after effects, because of the inevitable loss of trained drilling crews to other emergency activities," he added.

The committee estimated that it probably would require 41,000 to 50,000 wells a year merely to maintain productive capacity. The exact number would depend upon the proportion of productive wells to dry holes and the quality of the successful wells.

"Improved technology and more intensive development of proved reserves now enable the domestic industry to produce its reserves at a higher rate than in World War II," McCollum said. "This fact should prove of value in any emergency. It does not, however, permit any relaxation of the industry's efforts to find and develop enough new reserves to enable the industry both to keep pace with the steady growth in peacetime demand for petroleum and to maintain, at the same time, sufficient reserve capacity for any sudden emergency."

The committee's formal report emphasized the fact that its productive capacity estimates deal only with the quantities that could be produced at wells and natural gasoline extraction plants, regardless of whether sufficient transportation facilities exist to permit actual realization of such production.

"It is known from experience early in 1957 that transportation facilities in a number of fields, particularly in Texas, are not adequate to handle the full productive capacity," McCollum stated. "Therefore, it must not be assumed that all of the oil producible in the United States can be made available to markets on short notice."

The current study is the fourth productive capacity investigation undertaken by the NPC at the request of the government. The two preceding studies showed combined capacity for crude oil and natural gas liquids amounting to 8,200,000 bbl daily in January 1953 and 9,100,000 bbl daily in July 1954.

McCollum said that the margin between productive capacity and production in January this year was 2,406,000 bbl a day, compared with 2,212,000 bbl a day in July 1954. ★ ★ ★

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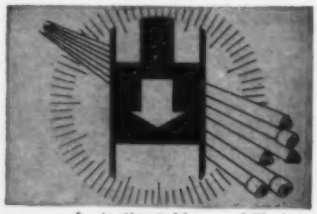
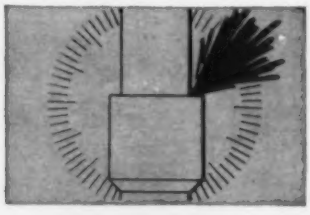


for testing tubing or drill pipe.



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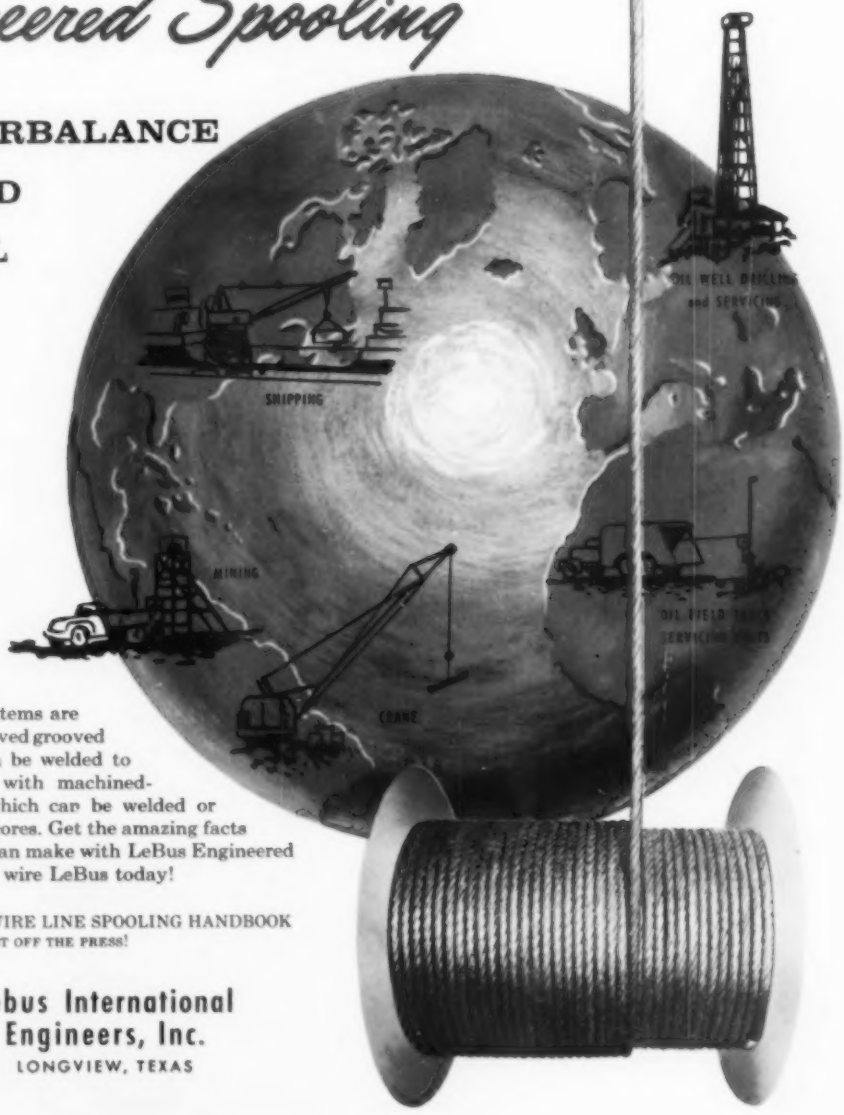

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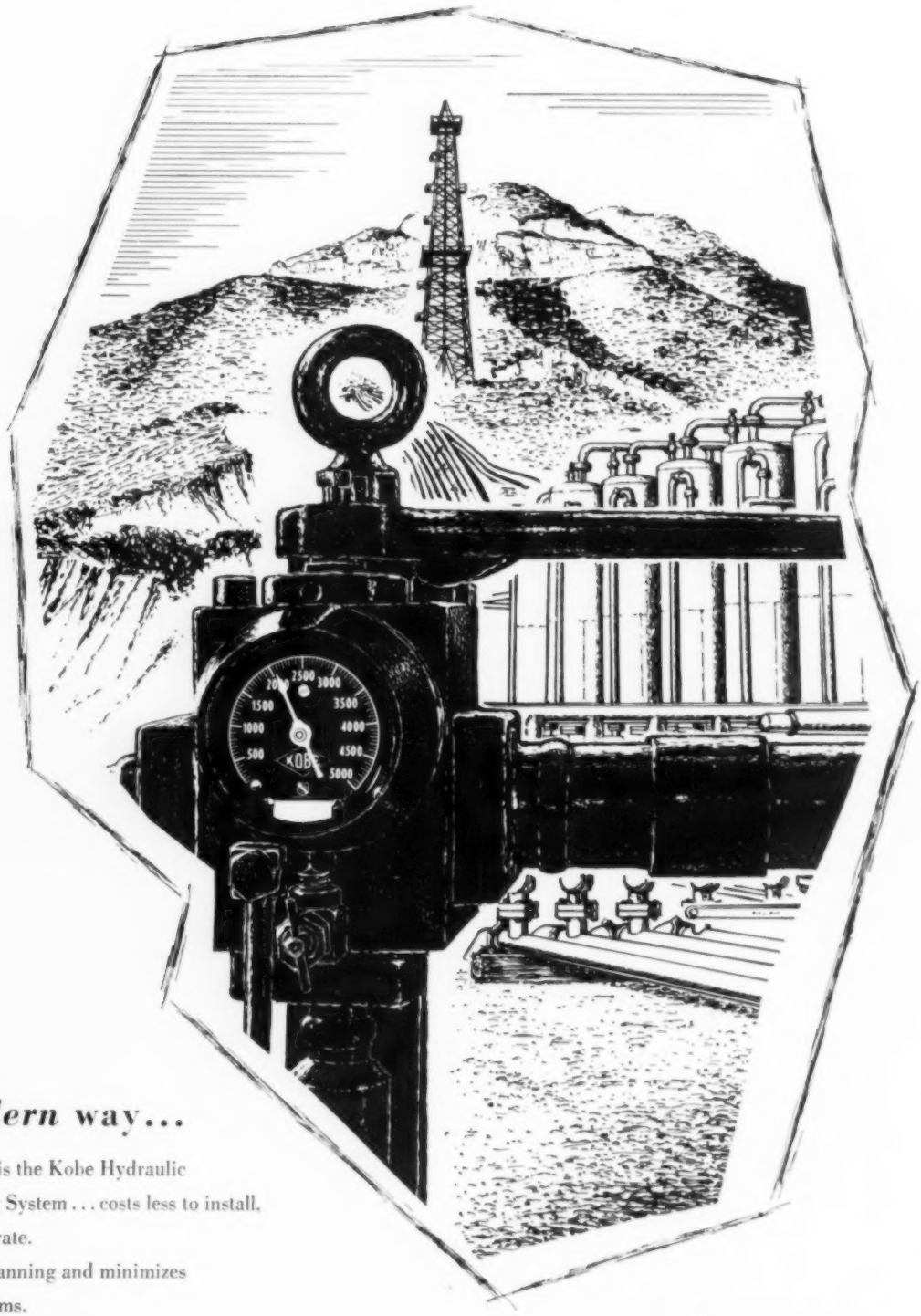

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Simplifies lease planning and minimizes production problems.
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Creole evaluates its

Revised Classification of Hazardous Areas On Drilling Barges

... in Lake Maracaibo, Venezuela

TWO YEARS AGO Creole Petroleum implemented a revised program for classification of hazardous areas on offshore barges used in its Lake Maracaibo, Venezuela, operation. Since the program has been in effect, there have been no electrical fires — in spite of the large increase of electrical equip-

Presented September 9-11 at the 1957 American Institute of Electrical Engineers Conference of the Petroleum Industry in Philadelphia, Pennsylvania, under the title: "Classification of Hazardous Areas for Electrical Installations on Barges Employed in Drilling Operations in Lake Maracaibo, Venezuela."

J. C. K. Muhlenberg
Creole Petroleum Corporation
Maracaibo, Venezuela

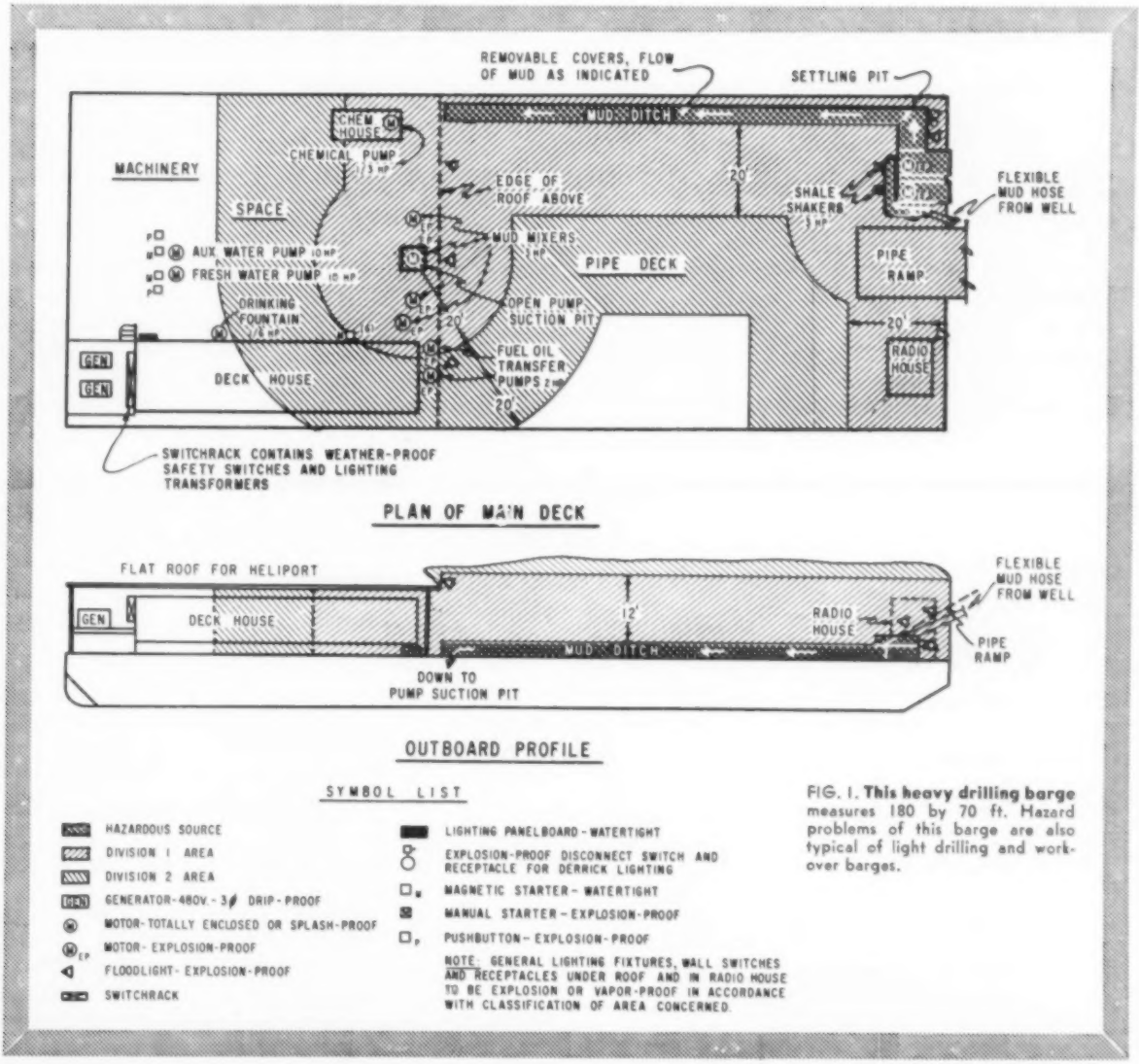

FIG. 1. **This heavy drilling barge** measures 180 by 70 ft. Hazard problems of this barge are also typical of light drilling and workover barges.

Just Published! "Analysis of 866 Cementing Jobs Using Cealment."

FIELD SURVEY SHOWS CEALMENT

Now—*proof from the field* that Cealment*, a Dowell-developed service using latex-cement, has been an important addition to the art of oil well cementing. During the period July 1, 1956 to June 30, 1957, Dowell performed 1,112 oil well cementing jobs in the United States using Cealment. A field study of these jobs, to determine the success-ratio of Dowell's latex-cement, has just been completed and published. Of the total jobs done, results were available on 866. And, of the 866, 656—or 76% were classified completely successful by the well owners or operators. A condensation of this field study is presented here for your information.

In Table I, all Cealment jobs are broken down into six types. Results are classified as: 1) Successful—where there was no doubt that Cealment performed as desired; 2) Partial Success—where latex-cement did not achieve the full measure of success desired, but did improve the overall condition of the well; and 3) Unsuccessful—where the material failed to perform as desired. *Job success-ratio is based on jobs classified as completely successful only.*

TABLE I

(In this survey a job is defined as a single application.)

APPLICATION	NUMBER OF JOBS	SUCCESSFUL	PARTIAL SUCCESS	UNSUCCESSFUL	SUCCESS RATIO
1. Squeeze	389	257	27	105	66.1%
2. Tail-In	273	255	5	13	93.4%
3. Liner	30	27	0	3	90.0%
4. Plug-Back	143	89	10	44	62.3%
5. Primary Cementing	22	21	0	1	95.5%
6. Lost Circulation	9	7	0	2	77.8%

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SUCCESSFUL IN 76% OF ALL JOBS

***SQUEEZE JOBS*—66.1% SUCCESSFUL**

MOST OF THESE JOBS WERE PERFORMED ON ZONES IN WHICH REGULAR CEMENT SQUEEZE JOBS HAD FAILED. One major oil company reported that where they were using Cealment, the first stage was successful—but when using regular portland two, three, or more stages were required. This comparison is based on squeeze jobs where *identical application techniques were used for both regular portland cement and latex-cement.*

***TAIL-IN JOBS*—93.4% SUCCESSFUL**

NEARLY ALL OF THESE JOBS WERE COMPLETED IN AREAS NOTED FOR SERIOUS COMMUNICATION PROBLEMS. The 93.4 per cent success-ratio reveals the high proficiency of Dowell latex-cement in preventing communication between closely-spaced zones.

An operator in Stonewall County, Texas attests the effectiveness of Cealment, ". . . we tried tailing-in with Cealment, covering the producing sections with Dowell latex-cement. We then perforated the zones and fractured between straddle packers to isolate each zone. On the 15 to 20 jobs completed to date using this method, we have had no communication trouble. We have been able to segregate perforations as close as eight feet with Cealment. We have used portland on 60 to 70 wells and were never able to segregate perforations closer than 18 feet."

***LINER JOBS*—90.0% SUCCESSFUL**

THESE JOBS ARE ADDITIONAL EVIDENCE OF THE VERSATILITY OF DOWELL LATEX-CEMENT. The number of jobs for this application is not large. However, the success-ratio shows that Cealment is especially suited to insuring the success of well completions.

***PLUG-BACK*—62.3% SUCCESSFUL**

TOO LITTLE LATEX-CEMENT LISTED AS CAUSE OF MOST FAILURES. JOBS WERE PERFORMED WITH DUMP BAILERS. A more accurate analysis of the point of water entry would have increased the success-ratio. In most cases, a second stage achieved success.

***PRIMARY CEMENTING*—95.0% SUCCESSFUL**

CEALMENT CAN BE USED IN ANY TYPE OF CEMENTING JOB. These 22 applications represent jobs where latex-cement was used to set the entire casing string. Of these 22 jobs only one was classified as unsuccessful.

***LOST CIRCULATION*—77.8% SUCCESSFUL**

SMALL NUMBER OF JOBS, BUT SIGNIFICANT IN DEMONSTRATING THE VALUE OF LATEX-CEMENT IN PREVENTING LOST CIRCULATION. Because of the specific problem of these jobs no direct comparison with other cementing methods can be made.

The slurry used in Cealment is a mixture of cement, liquid-latex and a special surface active agent. It overcomes most of the disadvantages of common portland cement. Dependable field performance under the most difficult conditions has proved the value of Dowell's latex-cement for the past two years. Its superior bonding strength, its high resiliency for perforating, and its resistance to contamination by mud make the latex-cement slurry especially suited for the critical area of your well.

For more information on Cealment—the most effective cementing service in the oil industry—or for service call the Dowell station nearest you.

For your personal copy of the "Analysis of 866 Cementing Jobs Using Cealment" write Dowell Incorporated, Box 536, Tulsa, Oklahoma. Or see your Dowell representative.

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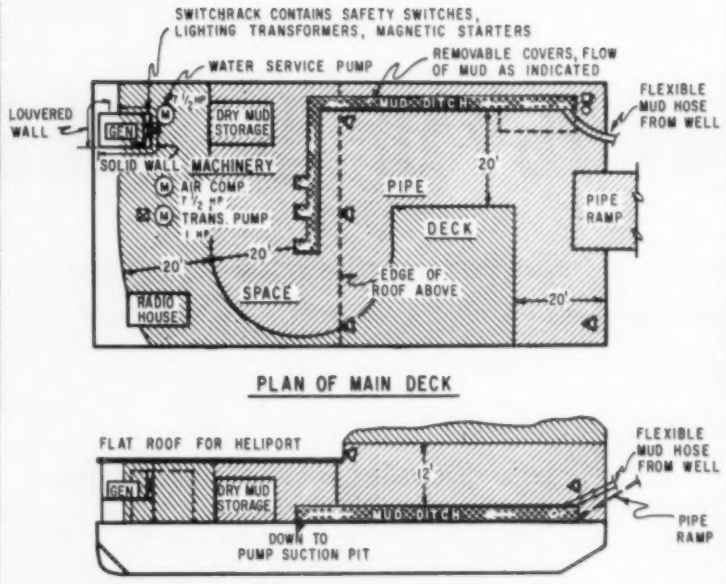


FIG. 2. **Typical well service barge** in use in Lake Maracaibo is similar to drilling barges, except that the shale shaker is omitted.

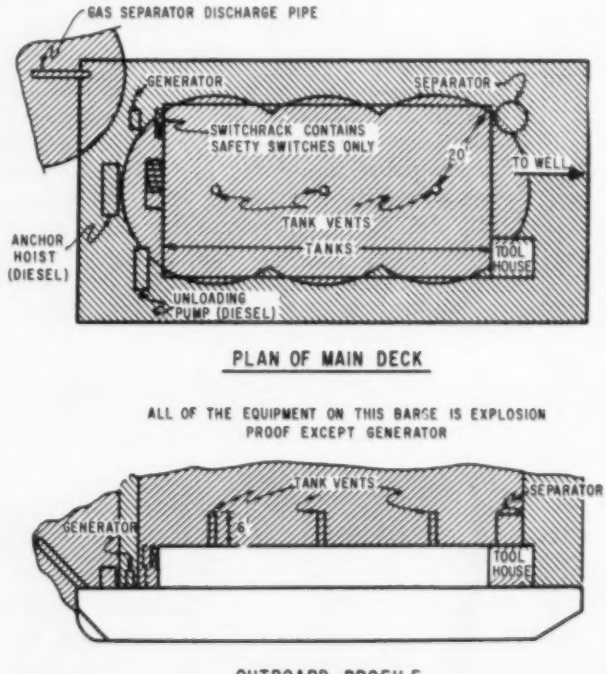


FIG. 3. **Test barge** may be classified as hazardous in every area. Location of the 4 kw a-c diesel generator posed a real problem.

SYMBOL LIST

- HAZARDOUS SOURCE
- DIVISION 1 AREA
- DIVISION 2 AREA
- GEN — GENERATOR-480V.-3ϕ DRIP-PROOF
- M — MOTOR-TOTALLY ENCLOSED OR SPLASH-PROOF
- M_{EP} — MOTOR-EXPLOSION-PROOF
- FLOODLIGHT-EXPLOSION-PROOF
- SWITCHRACK
- LIGHTING PANELBOARD-WATERTIGHT
- EXPLOSION-PROOF DISCONNECT SWITCH AND RECEPTACLE FOR DERRICK LIGHTING
- $\square_w$ — MAGNETIC STARTER-WATERTIGHT
- MANUAL STARTER-EXPLOSION-PROOF
- $\square_p$ — PUSHBUTTON-EXPLOSION-PROOF

NOTE: GENERAL LIGHTING FIXTURES, WALL SWITCHES AND RECEPTACLES UNDER ROOF AND IN RADIO HOUSE TO BE EXPLOSION OR VAPOR-PROOF IN ACCORDANCE WITH CLASSIFICATION OF AREA CONCERNED

ment on these units. So inclusive has the program been that allocations have been made for probable future growth of such equipment.

Gas problems in Lake Maracaibo are unique. Operations are primarily over water and Creole's problem is with a lighter-than-air gas, rather than more frequently found heavier-than-air gases found entrained in oil.

Growth of oil production in this area has been phenomenal. Increased size alone would have produced increased safety hazards. Coupled with this, however, are new methods and equipment that lend themselves to new problems.

The Problem Develops

Creole produced 6.5 percent of the world's crude oil in 1956 — 81 percent of this coming from offshore operations on Lake Maracaibo.

Prior to 1931 operations on the lake were essentially land type with the well platforms a short distance out in the lake. Board walks on piles connected the well platforms with the shore and also supported the oil and steam lines. The equipment necessary for the drilling and other operations, except the centralized boiler on the shore, was on the platform. With the introduction of the drilling barge in 1931 the tanks, pumps and boilers were all installed on a self-contained non-self-propelled mobile unit. The platform became solely a support for the derrick and drawworks. We were no longer restricted to a few hundred feet from the shore. Offshore operations were launched with all of the 72 by 110 miles of Lake Maracaibo as possible well locations.

Since 1931 the growth in lake operations has resulted in increased size, number and types of barges. At present they comprise a fleet of well over 40 heavy drilling, light drilling and workover, well service barges and various test barges.

Revision

Up to early 1955 an adequate and effective program by the electrical group for classification of hazardous areas had been in effect. This was substantiated by the absence of fires caused by electrical equipment. With the introduction of the diesel powered barges, however, it was felt that the existing program did not adequately cover the new situation. Not only were the expanding electrical installations increasing the potential danger from electrical equipment, but also new drilling techniques were increasing the gas hazard. Therefore it was decided to make a formal review of the situation and revise the existing program as required.

CLASSIFICATION REQUIREMENTS

The existence of a gas in itself indicates only that the situation warrants investigation, not necessarily that the area should be classified. The analysis of the problem is the investigation by determining:

1. Extent and type of gas.
2. Sources of ignition.
3. Designation of the areas.

Extent and type of gases. As mentioned, there are four types of barges. The operations performed, however, may be grouped into three general categories, all three of which present a common hazard — the liberation of gas from the fluids handled.

1. Drilling and workover — drilling a new well or deepening an old one.
2. Well Service — servicing a well to initiate, restore or increase oil production.
3. Test — cleaning out a new or deepened well, and measuring pressures and rates of flow of exploratory wells.

In drilling, workover, and well service operations drilling fluid is handled which may in itself liberate gas; however, the principal source of gas is not from the fluid. Rather it is the entrained subterranean gas which is brought to the surface by the circulating drilling fluid when drilling through or perforating into a gaseous formation. The quantity of gas entrained in the fluid may vary from practically none to completely replacing the drilling fluid in a blowout.

Testing a well involves the handling of crude oil on the test barge serving as a floating oil tank for the temporary storage of crude oil from the well. During filling of the tanks most of the gas is removed from the crude oil in the separator and vented off the end of the barge. The remaining gas passes out of the tank vents. The usual lighter-than-air gas rises but on occasions heavier gas is vented and settles to the barge.

In all three operations flammable gas is released to the atmosphere at the barge and, except in a few isolated cases, is lighter-than-air. The chemical analysis of a typical crude oil gas is:

Methane	73.0%
Ethane	11.7%
Propane	7.4%
Isobutane	1.2%
Normal butane	2.2%
Isopentane	1.0%
Normal pentane	0.9%
Hexane	0.8%
CO_2	1.7%
Specific gravity	0.806

Flash point below 150 F

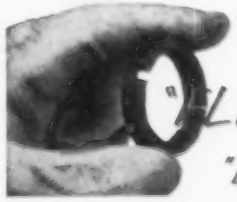
Perfect-Sealing—Step-cut design allows Flexite Rings to expand to a positive seal on the upstroke and fall freely on the downstroke.

Corrosion-Proof—Flexite Rings are machined from a special hard plastic composition which won't swell, corrode, nor disintegrate in sour oil.

Non-Swelling—Flexite Rings are precision ground for an exact fit in the barrel tube. No swelling nor soaking to size before running in.

Easy to Make Up—Flexite Ring plungers are easy to make up in the field. No special tools, fixtures nor instructions are necessary.

Wide-Design Rings—For deep-well pumping to afford greater sealing surface. Wide rings will fit standard A. P. I. rod or tubing pumps.



Harbison-Fischer
"FLEXITE" PLUNGERS
"Best Pumps in the Oil Patch"

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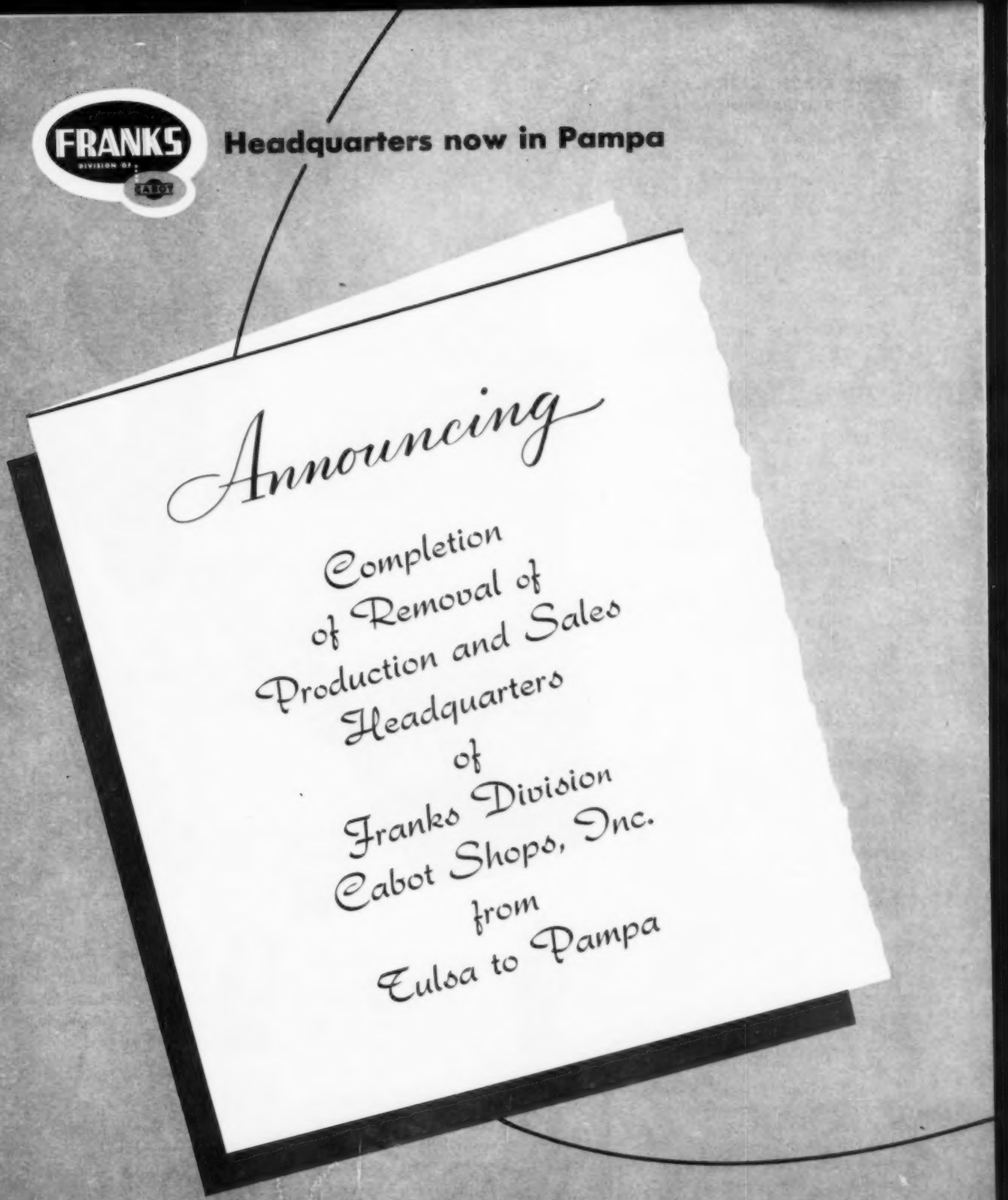
FRANKS
DIVISION OF
CABOT
Headquarters now in Pampa
Announcing
Completion
of Removal of
Production and Sales
Headquarters
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Franks Division
Cabot Shops, Inc.
from
Tulsa to Pampa

Better Production Facilities in Pampa Will Result in Even Better

Franks Units . . .

The Franks Division move provides a more modern and better equipped plant in Pampa, Texas (shown above). With the consolidation of Franks' and Cabot's production and engineering facilities, Franks Cruiser, Rocket, Clipper and Comet lines of well servicing units and drilling rigs will offer customers even better quality — longer life and lower cost maintenance. More engineering consultations will be held on improving and pioneering better ways of doing things. Franks will still maintain its 24-hour field service centers with stock-of-parts, and factory trained mechanics at strategically located points including: Odessa, Hobbs, Houston, Alice, Kilgore, Farmington, Tulsa, Lindsay, Seminole, Great Bend, Casper, Compton and Edmonton.

WELL SERVICING AND DRILLING UNITS
FRANKS
DIVISION OF
PAMPA, TEXAS
CABOT

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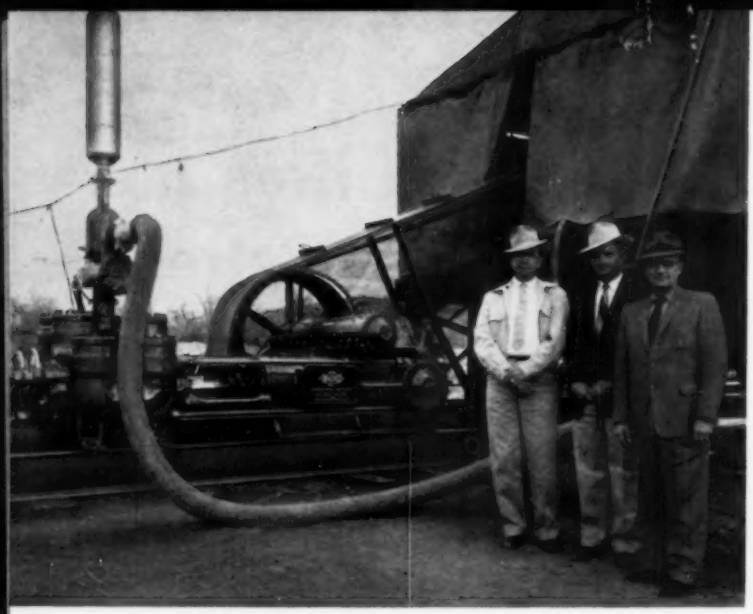
Cabot Shops, Inc.
P. O. Box 1101
Pampa, Texas



"This pump's performance was so satisfactory . . . bought a new (Wheland) HP-8000 pump for the smaller rig."

—J. W. Hastings

Here's the dependable Wheland HP-14000, still doing a fine job after 5 years in the field. Standing left to right, are Mr. J. W. Hastings, Owner; Mr. C. T. Coffman, Drilling Supt.; Mr. Joe Don Carlos, Wheland Rrepresentative.

J. W. HASTINGS
DRILLING CONTRACTOR
720-722 WICHITA NATIONAL BANK BUILDING
WICHITA FALLS, TEXAS

April 15, 1957

Mr. Gordon P. Street, President
The Wheland Company
Chattanooga, Tennessee

Dear Mr. Street:

I purchased one of your HP-14000 pumps five years ago which has cut a tremendous amount of hole with virtually no repair expense.

This pump's performance was so satisfactory that when I began acquiring new machinery, bought a new HP-8000 pump for the smaller rig.

Both of these pumps are still in operation and doing a satisfactory job.

I operate two rigs in North Texas area. We drill contracts, interest deals and for our own account, from 2,000 - 8,500 feet.

Yours very truly,

J. W. HASTINGS DRILLING COMPANY

J. W. Hastings

FIRST PUMP'S RECORD SOLD THE SECOND!

5-YEAR RECORD

OF OUTSTANDING PERFORMANCE

"virtually no repair expense"

—J. W. Hastings

WHELAND HP-14000

7½" x 14" DUPLEX SLUSH PUMP

350 Horsepower Nominal Input at 60 RPM
Discharge pressure with 7½" liners 838 PSI
Discharge pressure with 5½" liners 1627 PSI
Dependable Operation • Lower Maintenance
Delivers more pressure per pound of pump!

Write for Detailed Bulletins

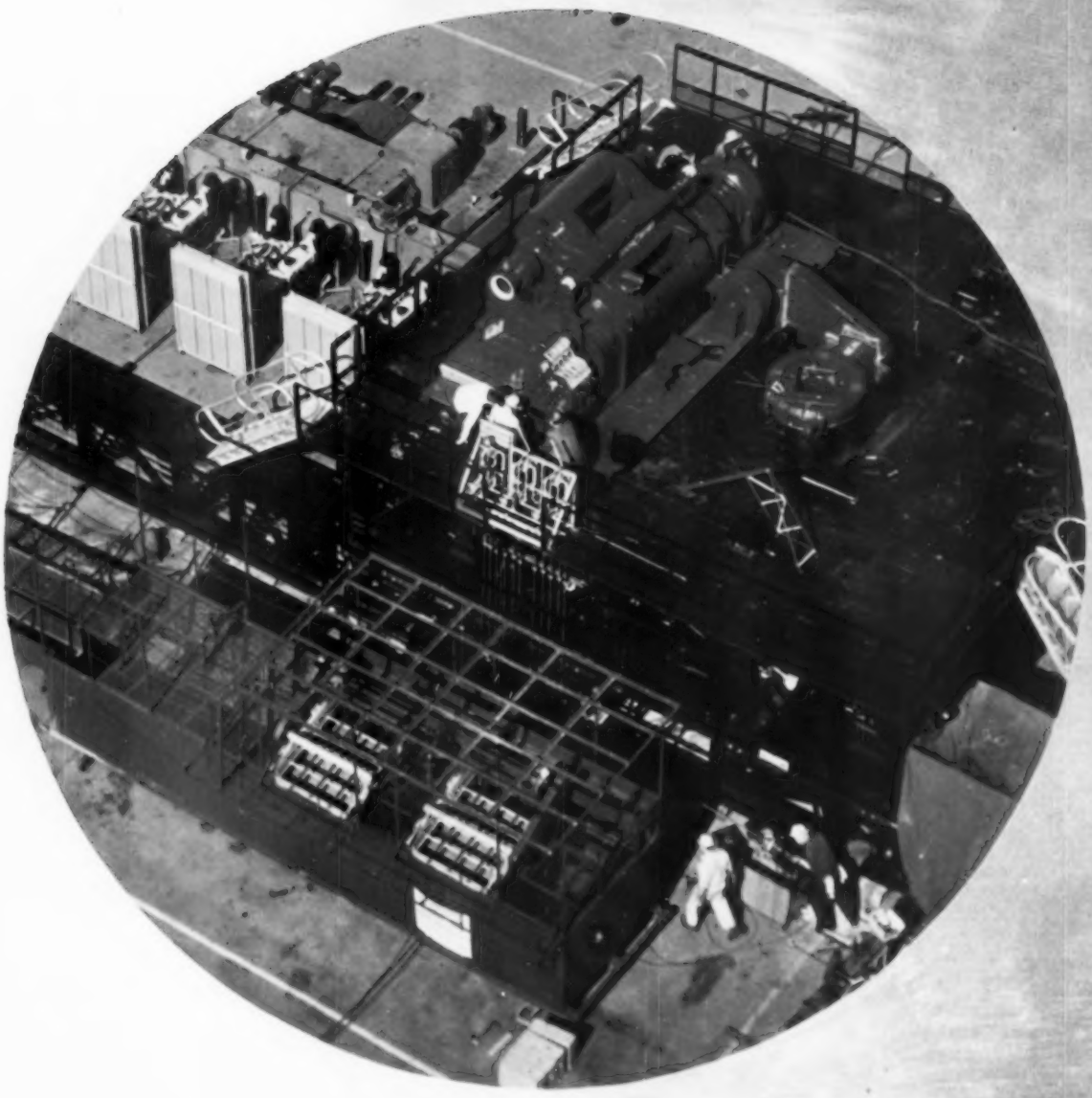
WHELAND

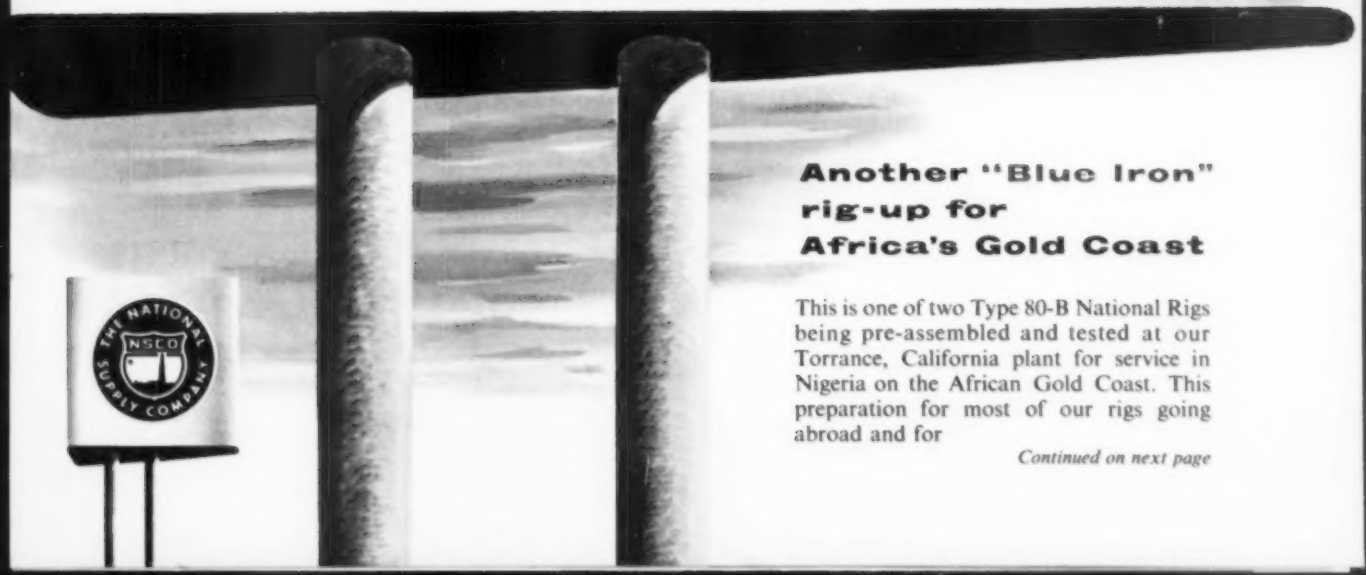
ROTARY DRILLING MACHINERY

THE WHELAND COMPANY
CHATTANOOGA, TENNESSEE, U.S.A.
DRAW WORKS • SLUSH PUMPS • ROTARIES
CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

DOMESTIC DISTRIBUTORS: INDUSTRIAL SUPPLY COMPANY, INC.—Main Office: Wichita Falls, Texas • HOUSTON OIL FIELD MATERIAL COMPANY, INC.—Main Office: Houston, Texas • JONES AND LAUGHLIN STEEL CORPORATION, SUPPLY DIVISION—Main Office: Drawer 2481, Tulsa 2, Oklahoma.

EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

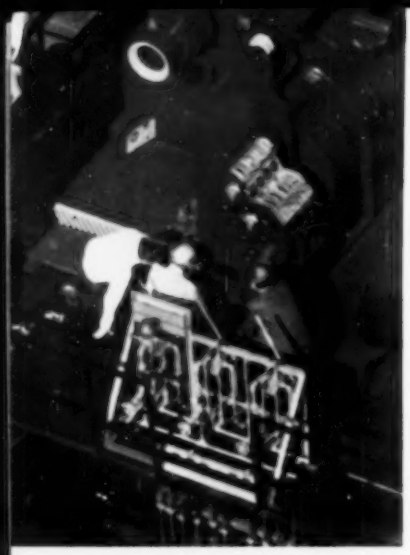




Another "Blue Iron" rig-up for Africa's Gold Coast

This is one of two Type 80-B National Rigs being pre-assembled and tested at our Torrance, California plant for service in Nigeria on the African Gold Coast. This preparation for most of our rigs going abroad and for

Continued on next page



Especially useful for larger rigs, National's optional rig-up service insures that every operating detail is anticipated.

Continued from previous page

many of our rigs destined for domestic service has a special name at National Supply. We call it *rig-up service*—and it has prevented many problems and saved time for contractors.

Here is how it works: At a National plant, store or your own equipment yard, we assemble—or direct the assembly of —the complete rig. Then, it is test-operated, lubricated and adjusted. If additional companion equipment or services are required, they are furnished *immediately*. Any problems that may delay you are promptly solved. Guide photos and paint-coded parts for fast re-assembly are supplied if you want them.

You can see how this rig-up service pays off in operations half-way around the world where service and parts are often days away. But it is becoming more important in domestic operations, too—when every day's delay plays havoc with estimated operating costs.

There's no doubt about the worth of preliminary rig-up service. Customers who use such National test-assembled rigs report *better rig-up time than previous field assemblies*.

This optional rig-up service is worth considering on any National rig shown on these pages. For either domestic or overseas operations, it can be the best insurance you ever bought. The National representative in your area, or National's Export Division office will be glad to give you complete details.

This is a portion of the rig assembly line at National Supply's Torrance, California, plant. National also manufactures smaller rigs at Toledo, Ohio.

Offshore? Deep drilling? Workover or servicing?

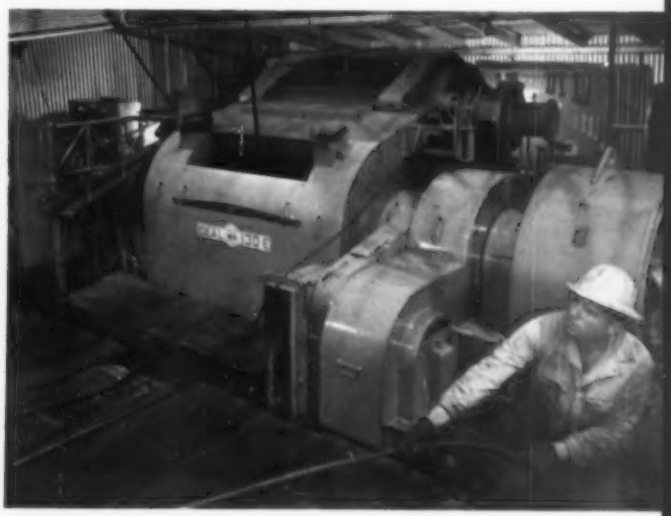
National rigs have extra performance built-in for every job

You can operate a National Rig in any land or water-based location and count on low-cost footage. You can drill shallow or deep, in hard or soft formations, and count on smooth-running action. And many of our customers believe that a National Rig is an asset in their contract negotiations.

What's behind all these advantages? Simply, top design and quality materials. Years of close association with your drilling problems insure correct, modern design. In manufacturing and assembly, the best materials and latest techniques are used. There's great attention to hundreds of construction details that can be all-important on a fast drilling schedule. In every way, extra performance is built into National Rigs. If you need application advice or service on location, you'll get it promptly from National—the world's largest supplier of oilfield machinery and equipment.

Before your next job, check on the operating economy of National Rigs. Ask the National Supply Store or representative in your area for complete details.

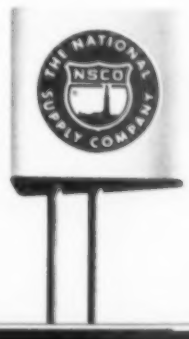
National's complete line of 10 rigs serves every drilling range—from the shallowest to the world's deepest wells. For truck or trailer mounted operations, the following National Rigs are available: T-8, T-8-S, T-12, T-12-S, T-20, T-20-S, T-32—in a range of horsepower from 80 to 320. For medium to deep drilling (on land or offshore), these National Rigs are available:



Type 55, 80-B, 110, 130 (an electric model is shown above), 160—in a range of horsepower from 550 to 2,000. Be sure to ask your local National Supply Store or Representative for complete information and descriptive bulletins on these top performers—proved in service throughout the world.

THE **NATIONAL SUPPLY** COMPANY

MAIN OFFICE: Two Gateway Center, Pittsburgh 22, Pa.
DIVISION OFFICES: Denver; Fort Worth; Houston; Toledo; Tulsa; Torrance
CANADA: The National Supply Company, Ltd., 200 F. W. Clark Building, 709 Eighth Avenue, West, Calgary, Alberta
EXPORT: 600 Fifth Avenue, New York 20, N.Y., U.S.A.; City Wall House, Chiswell Street, London E. C. 1
NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT



If you want top performance on truck or trailer-mounted equipment, see the next page...

A National T-32 trailer rig on location in Mississippi. National Rigs and Hoists utilize torque converter drives for smooth operation and a great variety of running speeds.

"Minimum downtime – faster operations"

. . . that's what operators say about National trailer-mounted rigs and truck-mounted hoists

You will, too, if you use these rugged smaller rigs! You'll get the same quality design features and construction you find in big National Rigs—the quality that insures top performance.

Mounted to suit your requirements, these National Rigs are exceptionally fast on rigs-ups and tear-downs. Their compact, *packaged* construction permits quick movement—and helps keep between-job downtime to a minimum.

Get all the facts now on portable National Rigs. There are four types—enough to meet every rig need in the trailer or truck-mounted horsepower range. Ask the National representative in your area for descriptive bulletins and performance records.

THE NATIONAL SUPPLY COMPANY

MAIN OFFICE: Two Gateway Center, Pittsburgh 22, Pa.
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CANADA: The National Supply Company, Ltd., 200 F. W. Clark Building, 709 Eighth Avenue, West, Calgary, Alberta
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NATIONAL BLUE OIL FIELD MACHINERY AND EQUIPMENT
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

Sources of Ignition

The existence of a gas does not constitute a hazard unless there is a source of ignition. The early barges had relatively few sources of ignition, having only lights and a steam driven generator. The lights were in vapor-tight fixtures and the generator was above on the pipe deck quite remote from the sources of hazard (Fig. 5). As the barges developed the various steam auxiliaries were gradually replaced by electric motors. With the introduction of the diesel powered barge all auxiliaries required electric motors. In other words there were now electrical motors and spark making electrical equipment throughout the barge.

Designation of the Areas

With the prerequisites for a hazardous situation established the next step is the designation of the areas. Under some conditions hazardous concentrations of flammable gas may occur near the shale shakers, pits, vents or ditches. Adjacent to this area is another area which normally does not have gas in hazardous concentrations. Beyond the latter area no hazard exists. Therefore, since the gas is a hydrocarbon the classification of area is Class I, Group D, Division 1, Division 2 and Non-hazardous, designated as follows: no hazard exists. Therefore, since the gas is a hydrocarbon the classification of areas is Class I, Group D, Division 1, Division 2 and Non-hazardous, designated as follows:

Division 1 area. The space 20 ft horizontally from the bow, open mud ditches, open mud pits, shale shakers or vents; vertically up to the roof or ceiling if this area is covered, or up to a height of 12 ft if the area is open, without a roof and freely ventilated to permit rapid dispersion of explosive or flammable gases.

Division 2 area. The adjacent 20 ft horizontally and 12 ft vertically from Division 1.

Non-hazardous. The remaining area of the barge.

APPLICATION OF CLASSIFICATION OF HAZARDOUS AREAS

Heavy Drilling Barge

Fig. 1 shows a 180 by 70 ft recently built diesel powered heavy drilling barge. Problems of this barge are typical of all heavy drilling, light drilling and workover barges. Sources of hazard, hazardous areas and pieces of electrical equipment are as indicated. The generator, lighting panel and switchrack are located aft in the non-hazardous area. When necessary to locate spark making electrical equipment such as starters, receptacles and pushbuttons in the Division 1 or Division 2 areas explosion-proof enclosures are used (Fig. 9). Conduit and the necessary seals to prevent the communication of gas from one area to another is eliminated by the use of marine armored cable, except for short pieces of conduit at the switchrack (Fig. 12).

As mentioned previously, during a drilling, workover or well service operation the drilling fluid may liberate gas. This fluid is required to control formation pressures to prevent blowouts. It also lubricates the drilling tool and carries cuttings to the surface. Fluid first passes through the shale shakers for removal of sizable solids. This is the first point where entrained gas in the fluid can be released to the atmosphere. Consequently the shale shakers represent the principal source of hazard. It is next carried aft in the mud ditch and drops into the open pump suction pit for pumping back to the well in a closed piping system (Fig. 7, 8, 9, and 10). Since all the gas is not released at the shale shakers the remaining gas escapes at the open pump suction pit, thereby making it a source of hazard. The mud ditch is

(Continued on Page B-161)

Best you can buy!

SPANG
DRILLING BITS

Die Forged . . . Completely Heat Treated They Drill More Hole for Less Cost

Made in Butler, Pa. . . . used 'round the world . . . SPANG BITS are BEST:

1. DIE-FORGED—gives uniform section from end to end.
2. FULLY HEAT-TREATED—they have maximum grain refinement assuring stronger pin, collars and blade sections.
3. TOUGH BLADE SECTIONS—means maximum penetration in hardest formations
4. PROPER DESIGNED WATER COURSES—providing better mixing, more room for cuttings and allowing faster drilling.
5. SEMI-DRESSED DRILLING ENDS—bits dress out to gage quicker with fewer heating
6. SELECT YOUR STEEL—made in high carbon and two grades of alloy steel—select the one best suited for your conditions.

SPANG & COMPANY
DEPT. O-7 BUTLER, PA.

For over 60 years manufacturers of Spang Weldless Jars and a complete line of Cable System Drilling and Fishing Tools for oil and gas wells, water wells, prospect drilling and shot blast holes.

USE SPANG BITS—
THEY ARE BEST
for YOUR OPERATION

SEE COMPOSITE CATALOG
for ENTIRE LINE!

Mudwonder valves on Gulf offshore rig. Mudwonder was selected here for low maintenance cost.

Why Mudwonders* outwork, outlast other mud valves

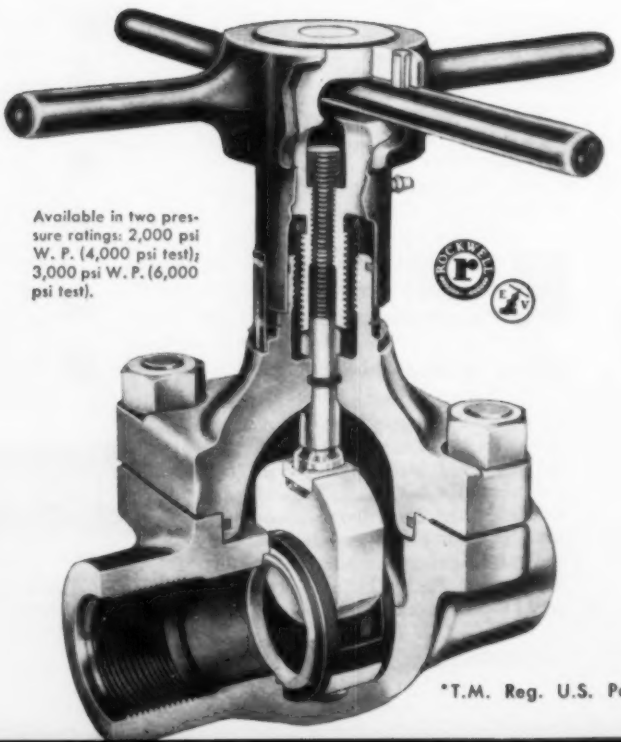
by Edward Valves, Inc.

Subsidiary of **ROCKWELL MANUFACTURING COMPANY**

How, in the space of two-and-a-half years, can a newly-introduced mudline valve become the favorite of thousands of oil well drilling rig operators throughout the country? This question looms large in the minds of those who see Rockwell-built Edward Mudwonder valves on drilling rigs all over the United States and Canada . . . and as far afield as South America and the Middle East too. The reason Mudwonder is stocked by virtually every oil field supply store—the reason most of the new Gulf offshore rigs are equipped with Mudwonder—is comparatively simple.

Easier to install, easier to maintain

Specially selected materials give Mudwonder parts an exceptionally long, trouble-free service life. Resilient buna-N inserts are molded integrally over steel wear rings and a hard-chromed steel gate. The stainless steel stem is a separate element, keyed into the gate to effect a sliding union which accommodates normal movement without danger of binding, even under rugged use. Any of these elements can be simply and quickly replaced, if necessary, without disturbing the piping hook-up. *Only one wrench is necessary.*



Available in two pressure ratings: 2,000 psi W. P. (4,000 psi test); 3,000 psi W. P. (6,000 psi test).

*T.M. Reg. U.S. Pat. O

Parts inventory simplified

Extra seats—and perhaps a spare gate in each size—are all the parts needed to keep Mudwonders in top shape. Seats and gates are interchangeable among pressure classes. Whenever maintenance becomes necessary, the procedure is simplicity itself: entire bonnet assembly unbolts and lifts off without disturbing the mudline hookup—and the working parts are exposed for inspection. Parts replacement can be made with practically no downtime.

No "sanding up"

Sand simply does not collect in the Mudwonder. Large, unrestricted openings into bonnet cavity permit a flow of mud to keep bonnet flushed out. Erosive wear from the mud is confined to the buna-N seat insert and the hard chromed gate. Resilience of buna-N permits use of steel wear rings to cut off the high-velocity flow of mud and absorb the abrasion, while the buna-N itself makes the seal.

Quick, positive shut-off

Gate is moved by a double-thread yoke bushing, which engages stem and bonnet threads simultaneously . . . gives 2-to-1 ratio for fast opening and closing. Dual action sealing allows line pressure to help make drop-tight shut-offs . . . prevents leaking or draining through valve when line pressure is removed. High closing loads are not necessary to make a tight seal. The Mudwonder sealing principle is such that the valve will hold rated pressure when the gate contacts the buna-N sealing surfaces. "Bumping" a Mudwonder closed—or using a "cheater"—is never necessary.

Protected bonnet threads

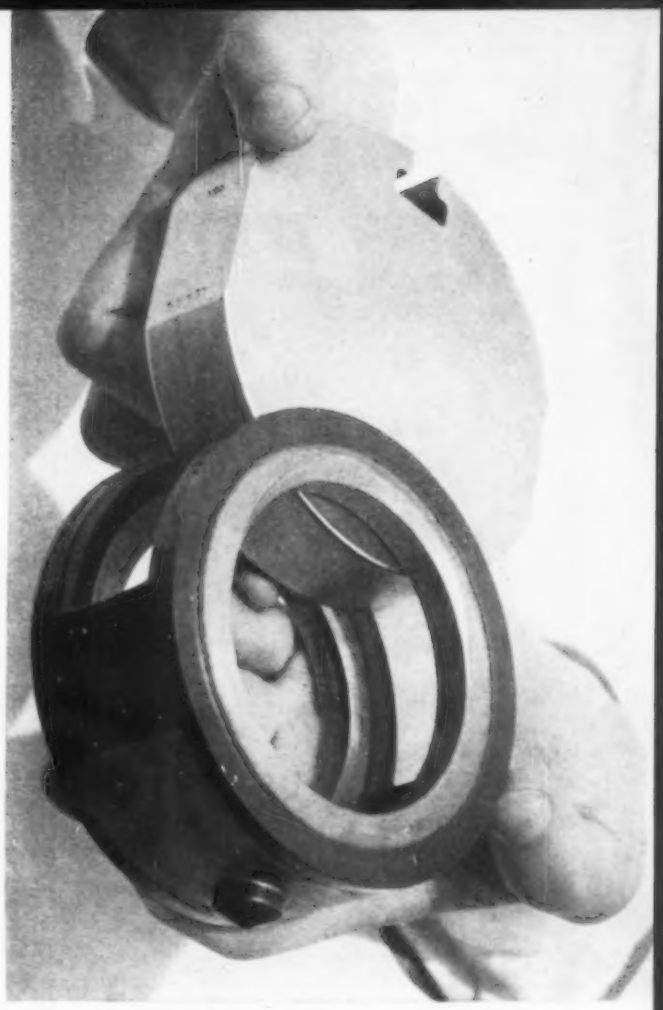
Stem, yoke bushing and bonnet threads are completely lubricated before leaving the factory, and are sealed against dirt, dust and weather. The inner stem seal is provided by a buna-N ring and leather back-up washer. A rigid shield and high-strength felt ring form the outer bonnet seal. A special relief vent in Mudwonder serves a three-fold purpose: (1) If valve is over-lubricated, excess grease escapes through the vent; (2) Mud escaping through the vent is the signal for replacement of worn or damaged "O" ring seal or back-up washer; (3) Because the vent equalizes air pressure in yoke bushing chamber as valve is opened or closed, you get easier operation.

Low operating torque

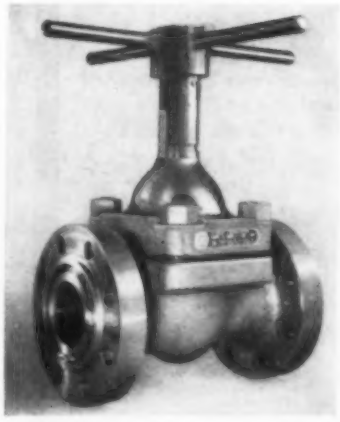
The hard-chromed alloy steel gate and the stainless stem are separate elements, slot-connected; this eliminates stem bending and binding due to line pressure on the gate. Low pitch threads reduce turning friction. The Impactor® built into the Mudwonder handwheel provides *twice* the torque of conventional handwheels . . . particularly valuable in opening the valve against extreme differential pressure. Hard chrome on the gate produces a smooth, low-friction sliding surface against the seat.

Easily available—competitively priced

Drilling men have tried Mudwonder—even abused it—to prove its economical superiority in operation, installation and maintenance . . . and this is why drillers all over the world say "Make mine Mudwonder!" Ask your favorite oil field supply store for complete information . . . or write, wire or call Edward Valves, Inc., East Chicago, Indiana.

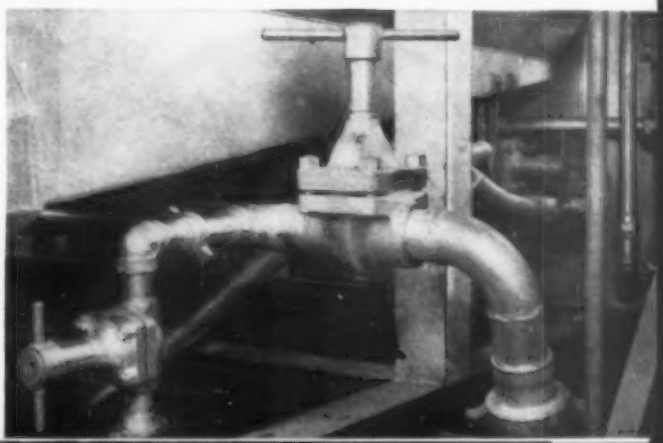


The "stout heart" of the Mudwonder absorbs wear and abrasion.

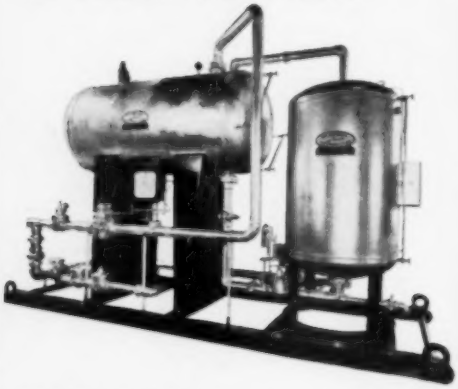


Mudwonder also available with flanged ends; illustrated is Fig. 3118, 3,000 psi W. P. (6,000 psi test).

Because valves are easy to operate and parts can be replaced without disturbing line, Mudwonder can be installed in any position.



THE
WELL TESTER®...
FOR DEPENDABLE, ACCURATE WELL TESTS



48WT-0107S-10CV Well Tester Pat. App. for.

The WELL TESTER provides a convenient, dependable and accurate means of measuring the volume of oil, water, and gas produced from oil and gas wells.

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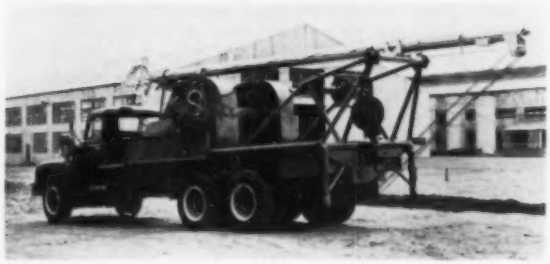

New Plant's First Unit Goes to Venezuela Firm

Franks Division, Cabot Shops, Inc., has produced its first well servicing unit in its new production shops at Pampa since moving from their original location in Tulsa to Pampa according to R. A. Baker, vice president and general manager.

It is a Cruiser Model, 658-TM single drum pulling machine sold to Servicios Pozos Anzoategui Co., Anaco, Venezuela of which J. M. Williamson is owner and operator.

The purchaser is a contractor doing well servicing work for several major oil companies in Venezuela.

The unit is designed for both rod and tubing pulling 6500 ft to 12,000 ft depths of 2½-in. tubing with standard 10 by 13-in. telescoping pipe mast.

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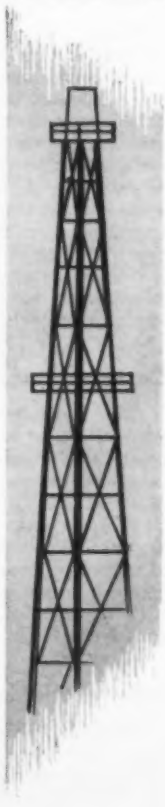

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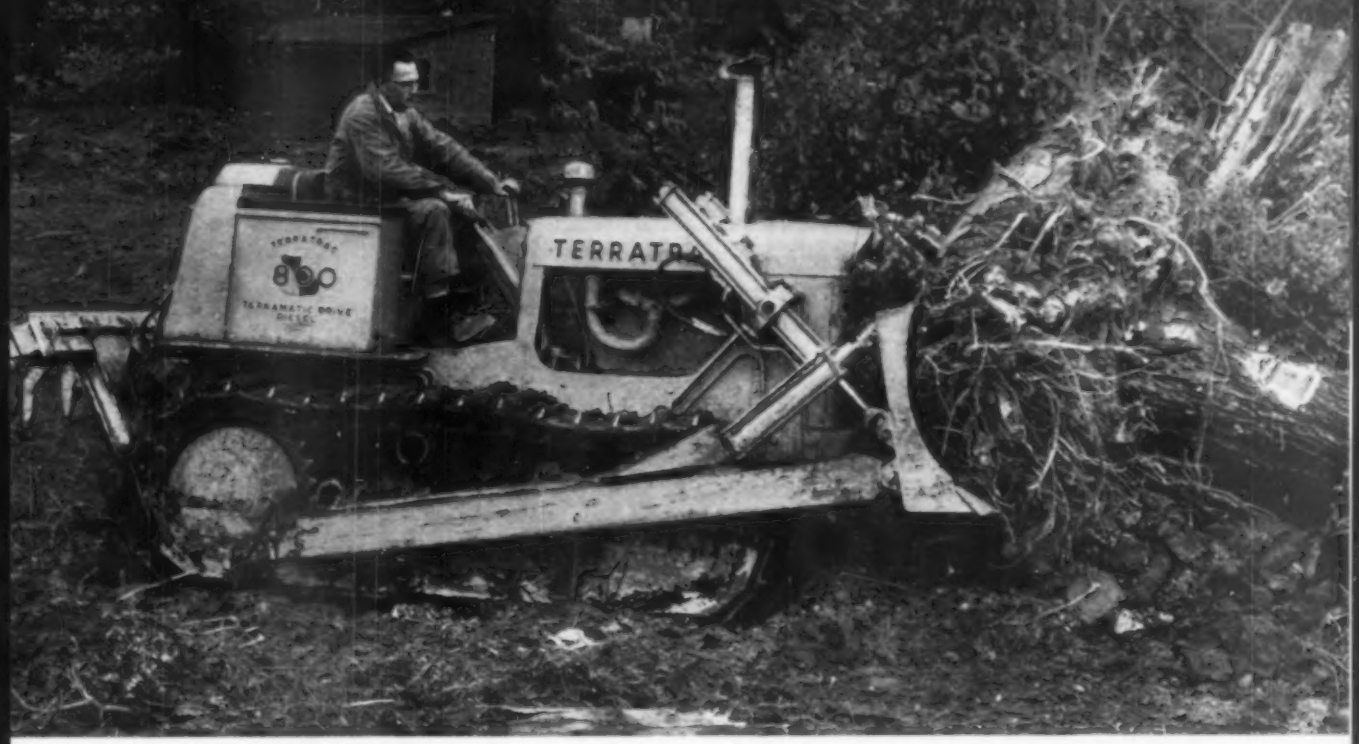

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Blade Width	8'	8'2½"	8'	7'11⅞"
Power-Tilt Blade..	YES	NONE	NONE	NONE
Engine HP (net)..	72 (80 Gross)	63	66.5	66
Torque Converter	YES	NONE	NONE	NONE
Max. lbs. push or pull	20,000*	10,700	15,485	12,600
Forward Speeds, MPH	(4) 0 to 6.0	(4) 1.5 to 6.1	(4) 1.5 to 5.5	(4) 1.7 to 5.9
Reverse Speeds, MPH	(4) 0 to 7.0	(2) 1.7 to 2.6	(2) 2.0 to 4.1	(2) 1.9 to 3.9
Power-Shift Transmission ..	YES	NONE	NONE	NONE
Power-Steer	YES	NONE	NONE	NONE
Power-Brakes ...	YES	NONE	NONE	NONE

*Assuming adequate traction

Above information based on latest specification sheets available to us at time of printing

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Part of this difference you can see "on paper" — in the accompanying chart. But the real difference comes "on the job", where the 800's *exclusive power-tilting blade* — plus greater speed and maneuverability — pay off in more work done per dollar of cost.

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FIG. 4. **Heavy diesel drilling barge** is shown here at the well platform. The barge is used for all equipment and operations except for rig floor activity.

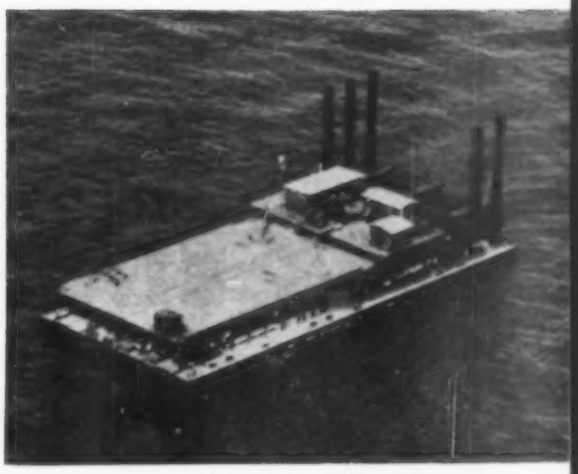


FIG. 5. **Double deck steam drilling barge** is similar to those in use on the lake since 1931. This one measures 110 by 60 ft.

(Continued from Page B-155)

normally covered but, for the purpose of classification of areas, it is reasonable to assume that at times a section of the cover may not be in place and therefore that part of the ditch becomes a source of hazard. Drilling fluid in storage on the barge does not liberate hazardous quantities of gas.

The area 20 ft from the bow, the end next to the well, is designated Division 1 because of the occasional releases of hazardous quantities of gas at the well head on the platform in routine operations. No attempt has been made to cover the abnormal situation of an "out-of-control" blowout.

Steam Powered Drilling Barge

The double deck steam powered drilling barge (Fig. 5) has the same gas problems and basic elements as the diesel powered unit with the exception of the steam driven generator located above on the pipe deck, fewer electric motors and different arrangement of the mud handling system.

Well Service Barge

Fig. 2 shows the layout of a typical well service barge. The component parts are similar to drilling barges except for omission of the shale shakers. Omission of these units has very little effect on the gas problem. Drilling fluid flows directly into an open settling pit at the head of the mud ditch. Entrained gas is liberated here instead of at the shale shakers as on a drilling barge.

In the design of this barge a gas-tight bulkhead was installed around part of the generator platform in order to increase the effective distance between the switchrack and the source of hazard.

Test Barge

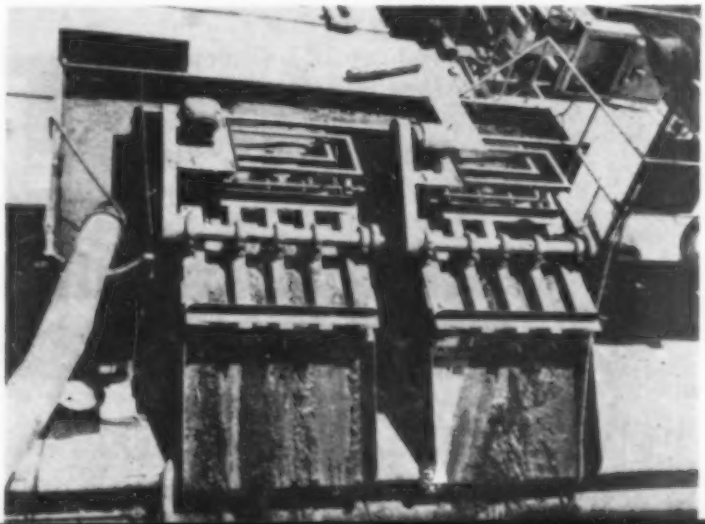
Fig. 3 shows a test barge. The electrical installation on this barge is simple, consisting of a 4 kw a-c diesel generator set and lights, but it is complicated by the fact that no part of the barge is a non-hazardous area.

The only space available for the diesel generator set was on the deck at the bow or stern or on top of the tanks. The later location was quickly ruled out because it would be only a few feet away from the nearest tank vent as well as being located in the most inconvenient place. This left only the bow or stern. Since attempts failed to have the tank vents relocated, either of these locations—bow or stern—placed the generator in a Division 2 area. Therefore the solution had to be found in the selection of the generator enclosure.

Naturally the first solution that came to mind was to use a hand cranked explosion-proof diesel generator set which is expensive as well as difficult

FIG. 6. **Diesel drilling barge** and an old-style test barge at a well platform.

FIG. 7. **Shale shakers** on drilling barges are at the bow. Note the flexible mud hose from well at the left. A floodlight is visible under the mud hose.



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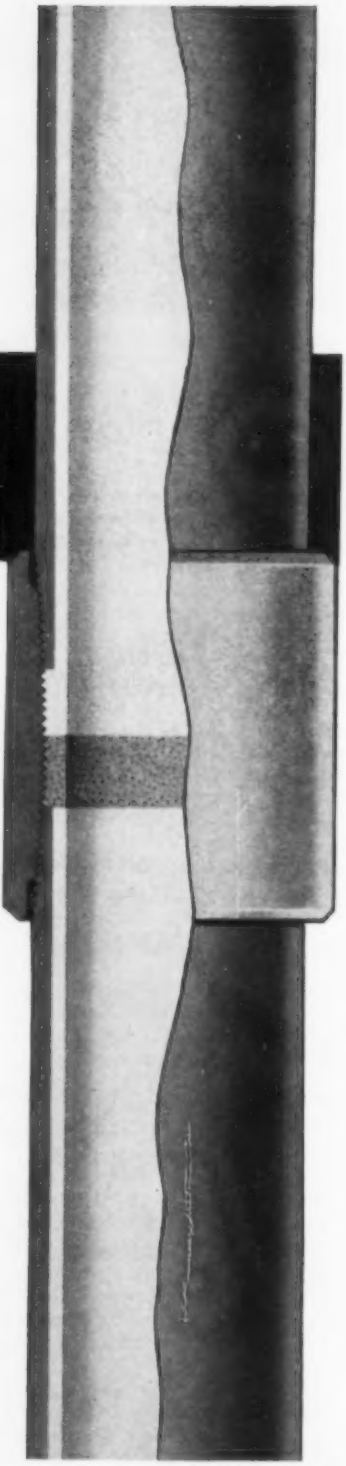

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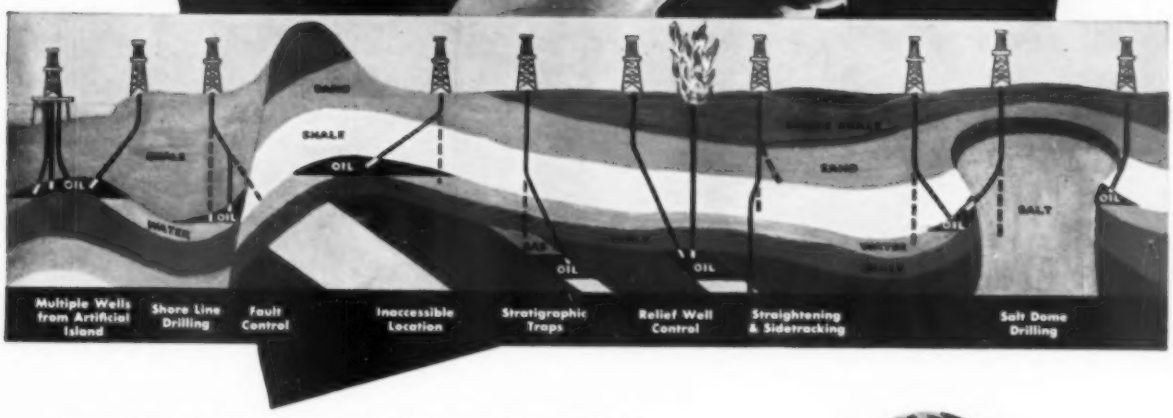

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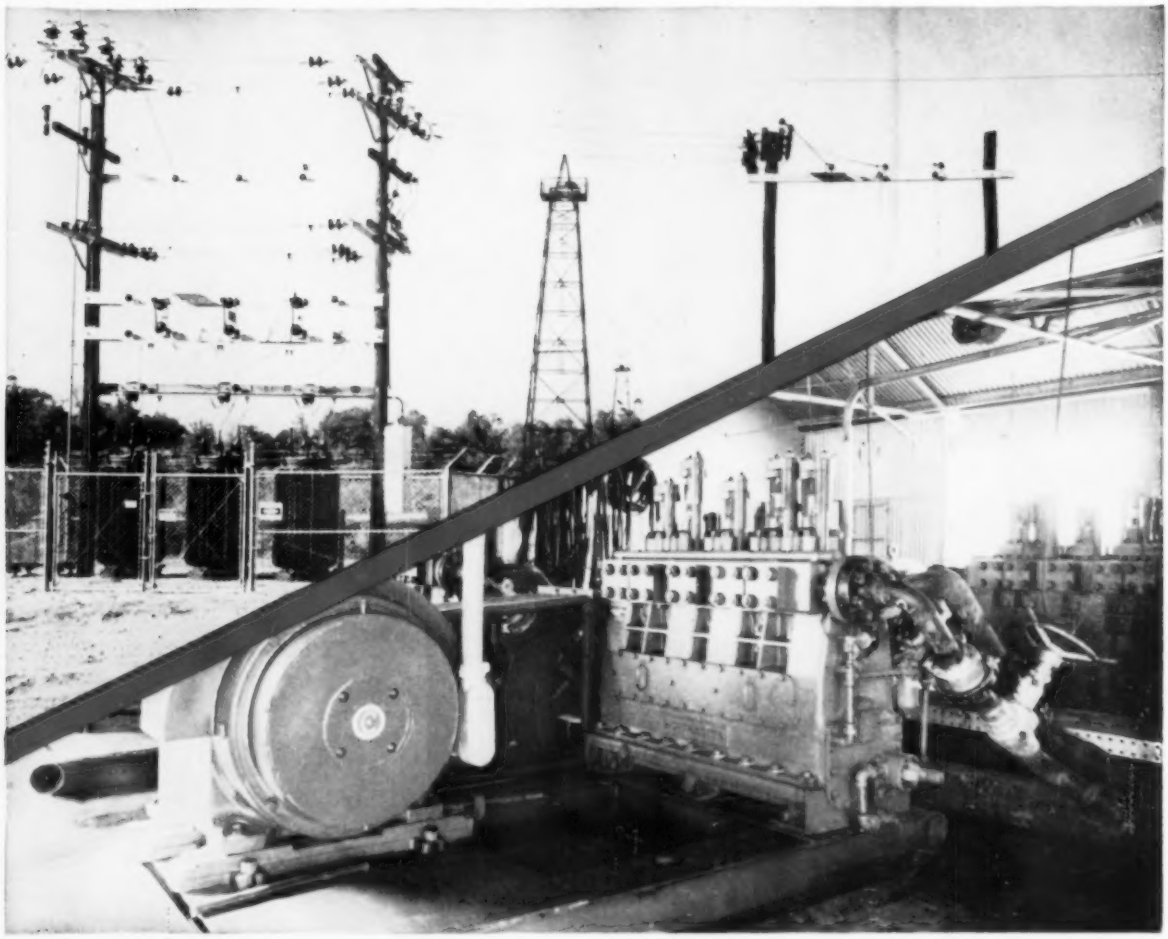

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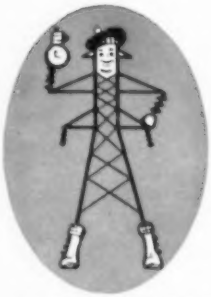

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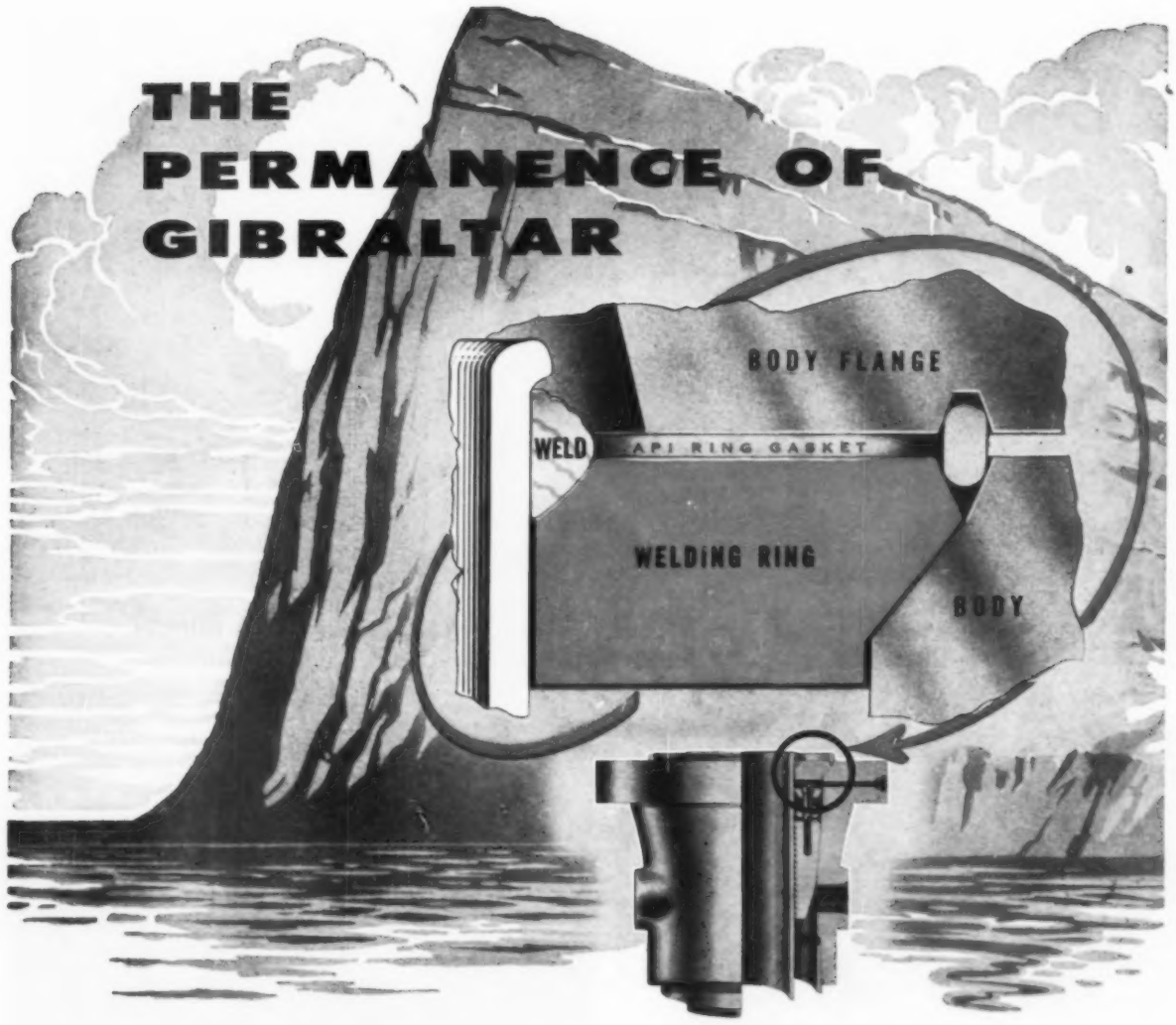

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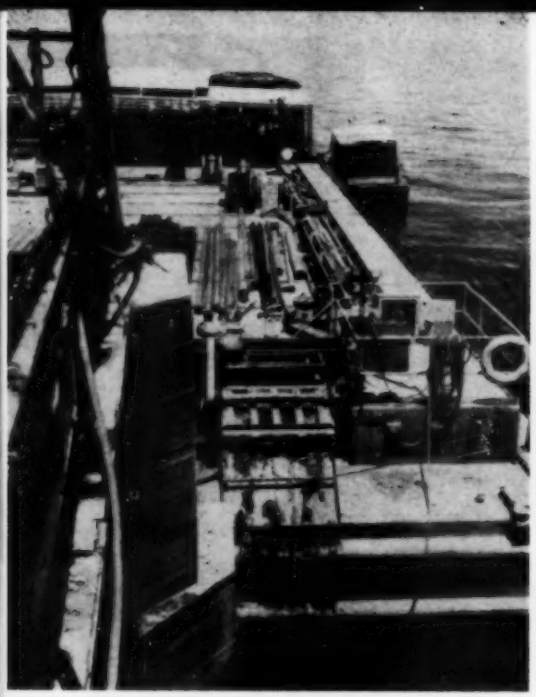


FIG. 8. **View of a diesel drilling barge** shows location of the shale shakers and the hazardous-classified mud ditch.

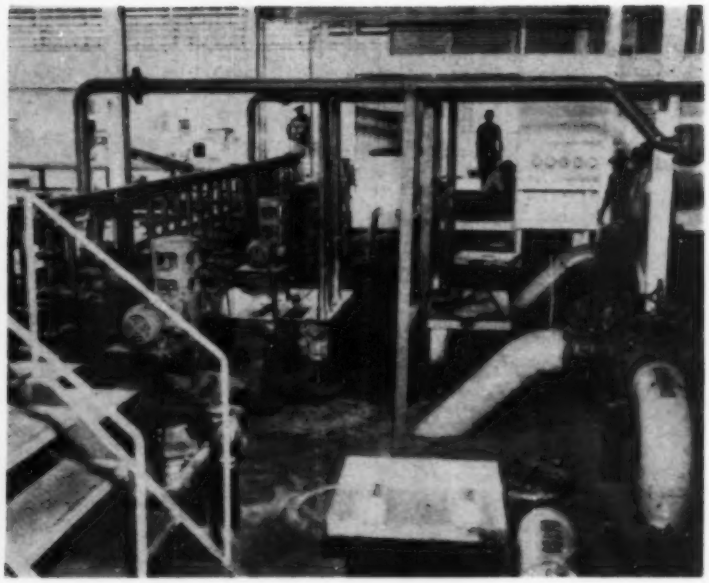
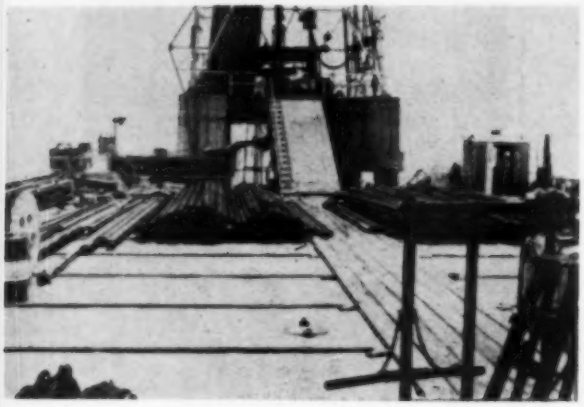


FIG. 9. **Mud mixers** and open pump suction pit (left center) are under the roof of the diesel drilling barge. Explosion-proof manual starters are visible in the background.

FIG. 10. **Pipe racks and well platform** are seen here from the diesel drilling barge's deck house. Flexible mud hose to the shale shakers are visible in center of picture.



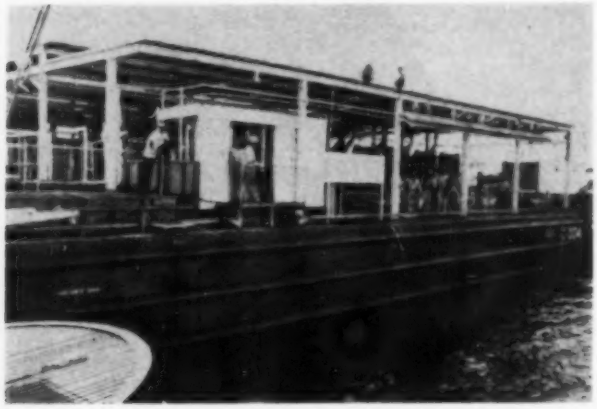
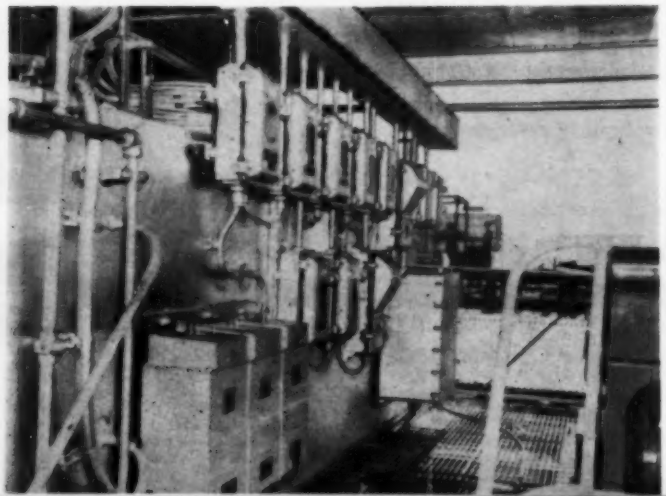


FIG. 11. **Open construction** is necessary on the barge. Roof and deck house are shown here.

FIG. 12. **Switchrack** of the diesel drilling barge. End of the diesel generator set may be seen at right of picture. New designs prescribe a weatherproof louvered generator house allowing use of general purpose enclosures for electrical equipment.



to maintain as explosion-proof. The other possible solution was to use a pressurized generator house. Unfortunately this was impracticable because of the difficulty of obtaining gas-free air to pressurize the house. Consequently the only choice was to specify an explosion-proof diesel generator set.

The actual solution came as a result of Creole's Purchasing Department's request for bids for an explosion-proof diesel generator set. One of the bids described an explosion resistant unit having no slip rings or commutator. The voltage regulator, rheostat and rectifier for d-c exitation are contained in a vapor-proof cabinet. In view of the infrequency of encountering heavier-than-air-gas and the difficulty of

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maintaining an explosion-proof generator as such, it was felt that the use of the cheaper explosion resistant unit was justified.

Another possible solution, except for cost, since apparently it is not manufactured in this small capacity, would have been a rotating permanent magnet field generator having no slip rings, commutator, voltage regulator or rheostat. Therefore this unit is in the category of an open induction motor and can be located in a Division 2 area.

Comparison with API Standard RP-500

The American Petroleum Institute Standard RP-500 gives us an opportunity to evaluate our original classification specifications even though a direct comparison cannot be made. The API Standard deals with heavier-than-air gases, whereas our problem is a lighter-than-air gas. It is pointed out in this Standard that there is extremely rapid dispersal of gas in a freely ventilated area. This includes a space, building or room having a roof and/or closed in on one side and is, undoubtedly, applicable to both lighter and heavier-than-air gases (Fig. 11). Therefore it seems that we have been too conservative in the designation of Division 1 area. Even so the total extent of our hazardous areas is comparable to those of the API Standard. Fortunately this excessive caution has resulted in practically no additional cost. A drastic reduction of the extent of Division 1 to, say, five feet from the source of hazard would change the enclosure of only a few floodlights, lighting fixtures and 1 to 3 hp-motors.

In view of the increasing amount of future electrical equipment on barges a revision of the classification specifications is to be undertaken in order to avoid unnecessarily specifying expensive explosion-proof equipment.

Evaluation Program

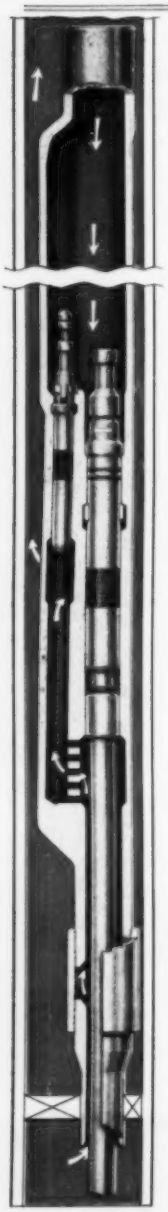
Since the introduction of the revised program for classification of hazardous areas into barge design in early 1955, considerable progress has been made in the electrical installations on barges. The new barges from the U. S. arrive with the installations in accordance with Creole's specifications. The older barges in service are being taken care of at overhauls. A beneficial result of the classification program has been the general improvement of electrical installations of all barges. When the changes required by the classification program are made during overhaul the opportunity is taken to renovate subpar installations.

Not only have the electrical installations been made safer but considerable accomplishment has been made in safer accessories to the diesel engines located in hazardous areas. They have had spark arresting mufflers for some time. The newer changes include mechanical rather than electrical or gas engine starting, non-electrical emergency motor shut-down devices, alarms and the elimination of the battery charging generator. These changes eliminate all electrical spark making devices from the engines.

The revised program for classification of hazardous areas has been in existence about two years. During this time Creole has continued to be free of electrical fires, therefore an appraisal on the basis of reduction thereof cannot be made. However, with the recent large increase in electrical equipment and the probable future growth, we feel the additional cost of the program is a good investment and certainly a necessity in order to continue the good record.

References

1. National Electrical Code 1956, Art. 500 and 510.
2. National Fire Codes, Volume II—Electrical —1956, Art. 500 and 510.
3. American Petroleum Institute Standard RP-500, 1st Edition, February 1955.
4. AIEE Publication No. 45 — Recommended Practices for Electrical Installations on Shipboard, December 1951.
5. Electrical Wiring of Drilling Barges and Offshore Structures—Presented by H. S. McIntosh, President—McIntosh Electric Supply Company, Beaumont, Texas. ★ ★ ★



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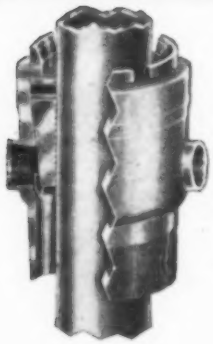

Fig. 91

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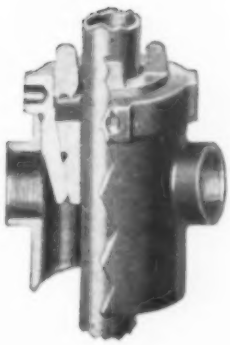

Type R

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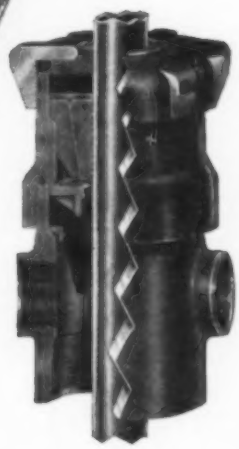

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The Larkin Type SR Tubing Head is a slip suspension head, equipped with a Neoprene Stripper which serves as a blow-out preventer and oil saver while tubing is being pulled or run. It is very suitable where higher pressures might be encountered.

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EXPLORATION ACTIVITIES

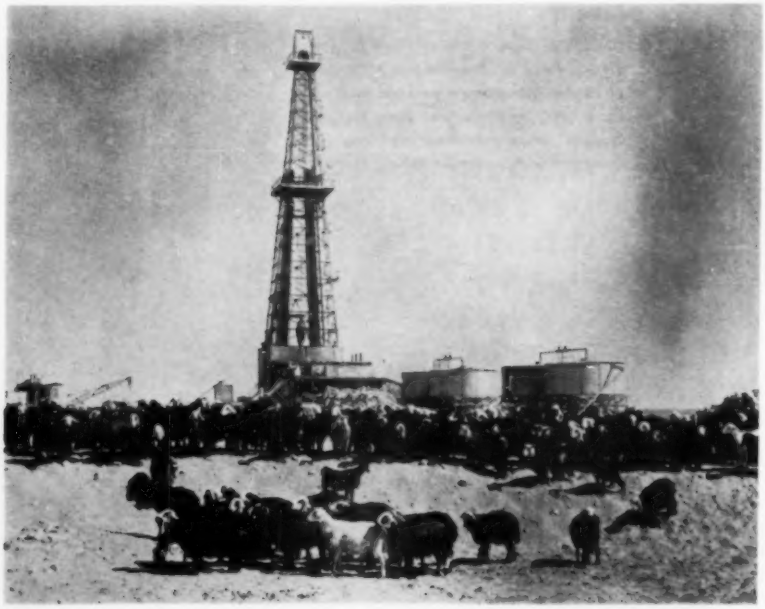
ALASKA

★ Humble Oil & Refining Company has announced that drilling has started on the Humble-Shell Bear Creek No. 1 in the Kanatak area of Alaska. The test well is being drilled by Humble for the joint account of Humble and Shell Oil Company. It is Humble's first drilling venture in Alaska. Drilling on the projected 12,000-ft test well started September 23. Site is on the Alaskan Peninsula about 350 miles southwest of Anchorage and is inland from Jute Bay.

★ Standard Oil Company of California, Western Operations, Inc., and Richfield Oil Corporation entered into an agreement for the joint exploration and development of their land holdings on the Kenai Peninsula of Alaska. Standard will be the operator and under the agreement will spend $30,000,000 over the next several years in exploring and developing the properties. Land holdings of the two companies on the Kenai Peninsula are substantial. Included in the agreement is the Swanson River unit, embracing 71,600 acres of Federal land on which Richfield last month completed the first discovery well on the Peninsula, 40 miles southwest of Anchorage, flowing at a rate of 900 bbl of oil per day. Location has been made for the drilling of a second well on the unit, approximately two miles south of the discovery well.

CANADA

★ Sunray Oil Company of Oklahoma and Pacific Petroleums Ltd. has successfully drillstem tested at its step-out well in the Montney field, British Columbia. The Montney No. 5 located in Lsd 14, Sec. 31, Twn. 86, Rn. 19, encountered the top of the Triassic "D" Zone at a depth of 4816 ft and drilled to 4844 ft. On test of the interval from 4819-44 ft the well flowed gas at a maximum rate of 11,295,000 cu ft per day through a ½-in. choke. Bottom-hole flowing pressure was 1700 psi with shut-in bottom-hole pressure of 1845 psi. Casing is being installed preparatory to completion of the well. Montney No. 5 is located on Permit No. 126 containing 149,440 acres. Sunray's interest in this permit is 50 percent.



A new well in Saudi Arabia is marked by this drilling derrick of the Arabian American Oil Company, which is drilling at Khurais in the great sand belt in Arabia known as the Dahana. The herd of goats are watering at a nearby trough provided by the company. The wildcat well, which was spudded in on August 2, 1957, is located approximately 170 miles southwest of Abqaiq, Aramco's principal producing headquarters, by overland route, and approximately 75 miles west of the center of the Ghawar field. The Khurais wildcat is being drilled as part of the exploratory program for evaluating the central interior of the concession area. Its objective is to penetrate and test the equivalent of all oil-bearing formations known in the Eastern Province of Saudi Arabia. As of October 1, the wildcat had reached a depth of 3956 ft.

NEW MEXICO

★ The Atlantic Refining Company, as operator of a 960-acre joint venture, announced the completion of a discovery well (State AE No. 1) in the North Crossroads area, Roosevelt County. The well produced 600 bbl of oil per day through a ¼-in. choke from perforation depths at 9650 ft to 9662 ft. The well had been drilled to a total depth of 9800 ft. Atlantic owns 67 percent of the joint area, with Gulf Oil Corporation, Magnolia Petroleum Company, and Skelly Oil Company owning the remaining ⅓.

UTAH

★ Continental Oil Company announced a significant two-mile extension of the White Mesa field in the Four Corners area of southeastern Utah, with the report on a half-hour drillstem test on a well that flowed at the rate of 1200 bbl of oil a day. The well, which extends the field on the Navajo Indian Reservation, is the Navajo A No. 10, San Juan County. It was tested at perforations from 5663 to 5712 ft. The well is nearly two miles west of the nearest producing well in the field, which was discovered in late 1956, and about 30 miles south of Blanding, Utah. Conoco has six producing wells in the field and a block of some 10,000 acres in the area.

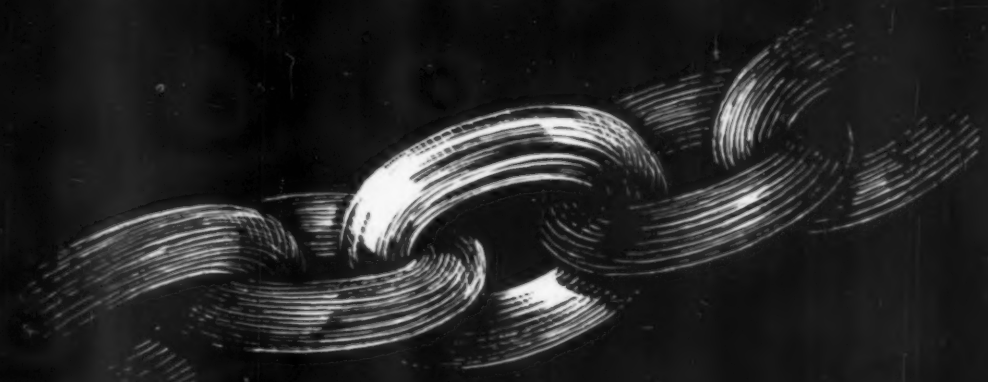
MISSISSIPPI

★ A 10,600-ft test for Pearl River County has been set by Cities Service Oil Company. The test is Crosby No. 1, located on a 6333-acre block approximately 35 miles southwest of Hattiesburg. The Cretaceous sandstone test is spotted in Sec. 31-1S-17W, two miles southeast of production in the East Angie field. Cities Service has approximately ⅔ interest in the test, with Crosby Mineral Company holding the remaining.

KANSAS

★ The opening of an Arbuckle oil pool in Barton County is reported by White Eagle Oil Company. The discovery well, the No. 1 Mary Demel, was drilled by a White Eagle subsidiary to total depth of 3332 ft and pumped 120 bbl per day on potential test of the Arbuckle lime. In addition, the Kansas City-Lansing Zone was successfully drillstem tested, yielding 1500 ft of clean oil during a 1-hour test. New pool is located to the west of the multi-pay Kraft-Prussa field.

found: the missing link in down-hole correlation . . .



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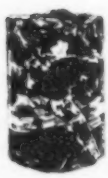

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Exploration

CALIFORNIA

★ General Petroleum Corporation's coring vessel, the M. V. Torry, has returned to Santa Monica Bay for the third phase of the company's offshore exploration in that area. Plans call for the drilling of one core hole, to be designated S. M. 4, about 500 ft from the company's first location in Santa Monica Bay. The first hole was abandoned short of its objectives because of mechanical difficulties. The newest coring operation will be conducted under a permit granted by the State Lands Commission. The water depth at the proposed location is approximately 130 ft.

★ Bishop Oil Company has spudded Williams Holding Company B No. 1, an extension well on a recently acquired 200-acre lease in the East Cat Canyon field of Santa Barbara County. Well is drilling ahead and has an anticipated total depth of 3000 ft. It is 4200 ft southeast of the company's recently completed Williams Holding Company A No. 1 well, which is currently pumping 45 bbl of 11 deg oil per day.

NORTH AFRICA

★ The Oasis Oil Company of Libya expects to drill a deep exploratory well in Libya. Spudding date has been set shortly after the first of the year. Oasis, a wholly owned subsidiary of the Ohio Oil Company, is the operating company for Libyan concessions totaling some 47,000,000 acres in which Ohio Oil, Continental and Amerada Petroleum each have an undivided ⅓ interest. The first exploratory well for the group in Libya is located on a 1,270,000-acre concession approximately 75 miles south of the Gulf of Sirte, on the Mediterranean seacoast.

The well may go as deep as 15,000 ft, and will look for oil below a geological feature prominent at the surface — a long north-south trending anticline. Oasis Oil geologists made a surface study of the feature, then followed with a seismograph survey which confirmed the surface work. International Drilling Company is assembling a rig in the U.S. to be shipped by boat to Libya for the test.

OKLAHOMA

★ Drilling of a second confirmation well has been commenced in Beckham County, in the southwestern part of the state near the prolific Springer formation discovery of Shell Oil Company and Wilcox Oil Company. The new well is the Patton No. 1 in Section 9-9n-22w on acreage adjoining the No. 1 Boyd discovery. The discovery well is on a 3200-acre, 5-section block known as the Boyd Unit. It was assembled by Wilcox and Shell is acting as unit operator, and Sinclair and others share in working interest. Boyd No. 1, finaled last month, was completed with an initial production in the Springer formation from 10,124 to 10,264 ft. Shell has estimated gas reserves on the 640-acre section on which the test was drilled to be 75 billion cu ft. The unit is eight miles southwest of the Elk City pool, which has been a prolific producer for the past several years.

VENEZUELA

★ Signal Exploration Company, operator of a 28,000-acre concession in Lake Maracaibo, Venezuela, for foreign subsidiaries of Signal Oil and Gas Company, Hancock Oil Company, Pure Oil Company, and Standard Oil Company of Ohio, reports six oil shows on their exploratory well, Centro 2X. Well is currently drilling ahead below 12,550 ft. Based upon inspection of well logs and mud ditch samplings, evidence of substantial oil staining and fluorescence have been found in six intervals of C Zone Eocene sands totaling some 200 ft. There has been no commercial testing of the well. There are also indications of oil, based on the same type of evidence, higher in the section, officials report.

★ Completion of SVSX Well No. 1 as an oil producer in Lake Maracaibo's Block No. 1 has been announced by the Venezuelan Sun Oil Company, Venezuelan Atlantic Refining Company, and Seaboard Oil Company group. Although tests on the exploratory well are still continuing, it is expected that production will settle to about 500 bbl per day of 36.7 deg sweet oil through a ⅜-in. choke. According to Venezuelan Sun, the operator, the well is flowing from perforations in the Mito Juan horizon from 11,050 ft to 11,074 ft. Total depth is 13,700 ft. The group's second Lake Maracaibo well, Timoteo No. 2 in Tract V-574, is still drilling.

★ Formation of Paria Operations, Inc., to operate a 152,000-acre concession in the Venezuelan waters of the Gulf of Paria, between the Venezuelan mainland and the Island of Trinidad, has been announced jointly by five U.S. oil companies. Drilling is already in progress. The five companies are The Texas Company, Continental Oil Company, and the Ohio Oil Company, each with a 25 percent interest in the concession, Cities Service Company, 16⅔ percent, and Richfield Oil Corporation, 8⅓ percent. Four drilling platforms have been erected in Paria Operations' concession area, and drilling of the first exploratory well began in mid-October.

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TEXAS

★ White Eagle Oil Company, Tulsa, reports the completion of an exploratory well drilled by its West Texas division in Fisher County. The White Eagle No. 1 Ada Mitchell flowed 139 bbl per day on potential test through a 20/64-in. choke. The well is located in Lot 14, J. N. Weakley Subdivision, Bastrop County School Land. It was drilled to total depth of 5622 ft and produces from perforations in the Strawn sand between 5568 and 5578 ft.

★ Texas American Oil Corporation's No. 1 Wilson Bryant, Midland County wildcat flowed through ½-in. choke 218 bbl of 40.7 deg per day on potential. Gas-oil ratio was 600 to 1. Production is from the Clearfork formation with casing perforated from 7278 to 7284 ft. The new producer extends the Block 39 Clearfork field 1½ miles northeast. The operator holds 1340 acres of leases around this well. It is about 18 miles south of Midland.

★ Upon completion of its State of Texas CE No. 1 as a substantial oil producer, The Texas Company announced the discovery of a new field in Andrews County, 1½ miles north of the Magutex field. The well flowed 375.7 bbl of 41 deg oil through a 33/64-in. choke from perforations at 12,514-19 ft in the Devonian. Tubing pressure was 75 lb and the gas-oil ratio 618 to one. Total depth of the drilling was 12,527 ft. Location of the new field is about 10 miles northeast of the town of Andrews, Texas.

★ Cities Service Oil Company has spotted a 4500-ft Canyon test in Stonewall County on an 18,500-acre block. The test is Flat Top "164" B No. 1, nine miles southeast of Aspermont and one mile southeast of production in the Flowers pool. The spotting is 660 ft from the south line, 660 ft from the west line of Sec. 164, BBB&C RR Co. survey. Cities Service has an approximate ⅔ interest, with Lone Star Production holding the remaining interest.

★ Oil and Gas Property Management, Inc., Dallas, Texas, has staked the first of eight locations to be drilled in Section 1, Block B-23, PSL Survey, in Crane County. The wells will be drilled for Seminole Oil and Gas Corporation, Dallas, Texas, and Milestone Drilling Company of Midland, Texas. Operator announced today that Milestone is rigging up on the first location, Well No. 1-M, 330 ft from the north line and 1080 ft from the west line of Section 1.

★ Parker Petroleum Company, Inc., completed its Ben Hill No. 1-A well, a high-pressure gas discovery in Roberts County in the Texas Panhandle, culminating 11 months of work which saw the original well blow out and flow uncontrolled for several weeks earlier this year. The discovery well, located in SW SW of Section 146, Block 42, H&TC Survey, has been dually completed in the Upper Morrow sand at 9832-51 ft and in the Lower Morrow at 10,906-28 ft. The Upper Morrow sand from 9832-9851 ft had an open flow gas potential of 7,600,000 cu ft with 3 bbl of 53 deg condensate per million. The Lower Morrow from 10,906-28 ft had an open flow of 23,000,000 cu ft with 79 bbl of 55.5 deg condensate per million through a ½-in. choke. The well is about 12 miles from nearest production.

CUBA

★ The Atlantic Refining Company is beginning a wildcat well in the Pinar del Rio Province of Cuba. Located near the town of Los Palacios some 60 miles southwest of Havana, the well is expected to reach a depth of approximately 9000 ft. This is the first of a series of tests on Atlantic's substantial full interest holdings in Pinar del Rio Province after completing extensive seismic exploration during the past year. The Jones Brothers Drilling Company of Shreveport, Louisiana, has been selected as contractor for this first well.

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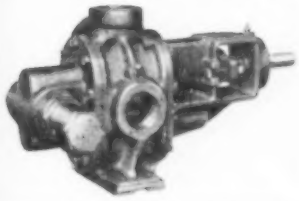

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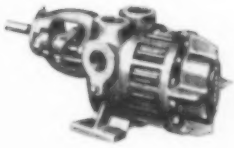

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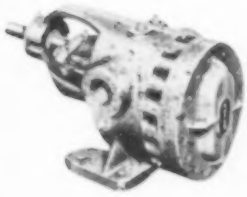

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What's doing in DRILLING

★ **Continental Marine Exploration Company** has acquired all of the drilling equipment of Morris and Hamilton, Inc., Houston — based offshore drilling contractors. R. D. Ricketts, president of Fish Northwest Constructors, Inc., announced his firm had completed the purchase through its wholly owned subsidiary, Continental Marine. The acquisition marks the first move of the Fish companies into offshore operations. Continental Marine equipment will initially include one offshore mobile drilling platform, one bay drilling barge and three land rigs. The Mobile "M & H No. 12," built in 1956, is a submersible hull type for open sea operation to medium depth waters. The platform was built in Houston and has successfully survived four coatal storms while drilling in the Gulf of Mexico. At the present time, the offshore mobile is drilling under contract to The Texas Company off Timbalier Island, Louisiana, in the Gulf of Mexico. Construction of a second bay barge capable of drilling in deep inland waters will begin soon.

★ **Howell, Holloway & Howell,** Gulf Oil Corporation, Tekoil Corporation, and Kenneth A. Ellison are going to make a try for the world's drilling depth record now held by Richardson & Bass by a 22,570 ft well in South Louisiana. The group has staked location for the No. 1 Anadarko Basin in Caddo County, Oklahoma, which is scheduled to go to 24,000 ft. Well is to be about four miles southeast of the Eakly townsite, with operators holding about 40,000 acres around the test. Howell, Holloway & Howell will drill the well with company tools.

★ **Drillers in East Texas** will note a shortened WOC — waiting on cement — period as a result of a recent Railroad Commission Ruling. Acting on an application of Phillips Petroleum Company, the commission ordered that it was no longer necessary for cement in Henderson field casing and production strings to stand for 48 hr before initiating tests or drilling the plug. A 24-hour setting period was termed adequate in the Rusk County field because of recent technological advances.

★ **"Jet bit drilling hydraulics"** is a new book presenting a series of easily read two-color graphs and charts aimed at solving flow resistance problems most commonly encountered with jet bits, and should be of interest to all drilling engineers. Basic subjects covered are: Annulus velocity, jet velocity, pressure loss in drill pipe, viscosity correction, loss at contraction in pipe, loss at jet nozzle, pressure loss in annulus, loss at contraction in annulus, mud weight correction, pump output, and hydraulic horsepower. In addition a number of perforated computation forms are bound into the book to simplify calculations. Bulletin is put out by Chicago Pneumatic Tool Company.

★ **AAODC** has a new catalog of "Publications-Services-Films" available. The catalog lists 34 publications of the association on drilling economics, technology and safety. Sound-color motion pictures, 16 mm, include 9 on drilling safety, 8 technical training, and 3 supervisory training films. Brief descriptions and prices are given. Copies are available by writing the association's office, 505 North Ervay Street, Dallas 1, Texas.

★ **Four Corners chapter** of the American Association of Oilwell Drilling Contractors has elected Robert E. Jackson of Empire States Drilling Corporation as chairman for the 1957-58 term of office. New slate of officers were elected at a meeting September 17, with some 55 contractors attending. This is the fourth meeting since the group was organized in May with a nucleus of 13 contractors represented. Other new officers are: J. M. Riddle of Moran Bros., Inc., first vice chairman; J. W. Woodward of Great Western Drilling Company, second vice chairman; Joe D. Christesson of Arapahoe Drilling Company, third vice chairman, and Troy J. Rogers of Miracle-Fifer Drilling Company, fourth vice chairman. Kenneth K. Swanson of Moran Bros., Inc., is secretary-treasurer.

★ **International Drilling Company, N. V.** has received a contract from the Oasis Oil Company of Libya to drill a deep test in Libya shortly after the first of the year. The proposed wildcat, which may go to 15,000 ft, is located on a 1,270,000 acre concession about 75 miles south of the Gulf of Sirte, on the Mediterranean seacoast. International is now assembling a heavy duty rotary in Houston, Texas, soon to be crated and shipped to Libya. Oasis is the operating company for Libyan concessions totaling 47,000,000 acres in which Ohio Oil, Continental and Amerada Petroleum each have an undivided one-third interest. Oasis geologists spotted the well on a geological feature prominent at the surface, a long north-south trending anticline.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company

	Sep. 23	Sep. 30	Oct. 7	Oct. 14
Alabama	4	2	4	4
Arkansas	26	27	23	27
Arizona	1	1	1	1
California	97	98	95	90
Colorado	69	63	56	60
Florida	1	1	1	1
Georgia	0	0	0	0
Idaho	0	0	0	0
Illinois	71	63	61	63
Indiana	8	6	11	11
Iowa	2	2	2	2
Kansas	148	151	161	162
Kentucky	10	8	10	10
North Louisiana	63	61	56	57
South Louisiana—Land	292	276	291	283
South Louisiana—Offshore	95	90	89	92
Total Louisiana	450	427	436	432
Maryland	1	1	1	1
Michigan	11	8	11	11
Missouri	0	0	0	0
Montana	33	33	34	40
Mississippi	40	42	41	41
Nebraska	34	36	36	28
Nevada	0	0	0	0
New Mexico	155	148	141	139
New York	0	0	0	0
North Dakota	40	40	36	38
Ohio	0	0	0	0
Oklahoma	266	253	257	251
Oregon	1	1	1	1
Pennsylvania	13	14	11	13
South Carolina	0	0	0	0
South Dakota	0	2	1	1
Tennessee	1	1	1	1
Texas Gulf Coast—Land	195	181	196	178
Texas Gulf Coast—Offshore	3	2	4	4
West Texas	357	349	359	351
North Texas	279	271	280	283
East Texas	53	49	59	60
Total Texas	887	852	898	876
Utah	64	68	71	66
Washington	1	1	1	1
West Virginia	4	2	3	3
Wyoming	73	82	83	78
Virginia	1	0	0	0
Total U. S.	2512	2433	2488	2452
Western Canada	201	194	190	165
Eastern Canada	3	3	3	3
Grand Total	2716	2630	2681	2620

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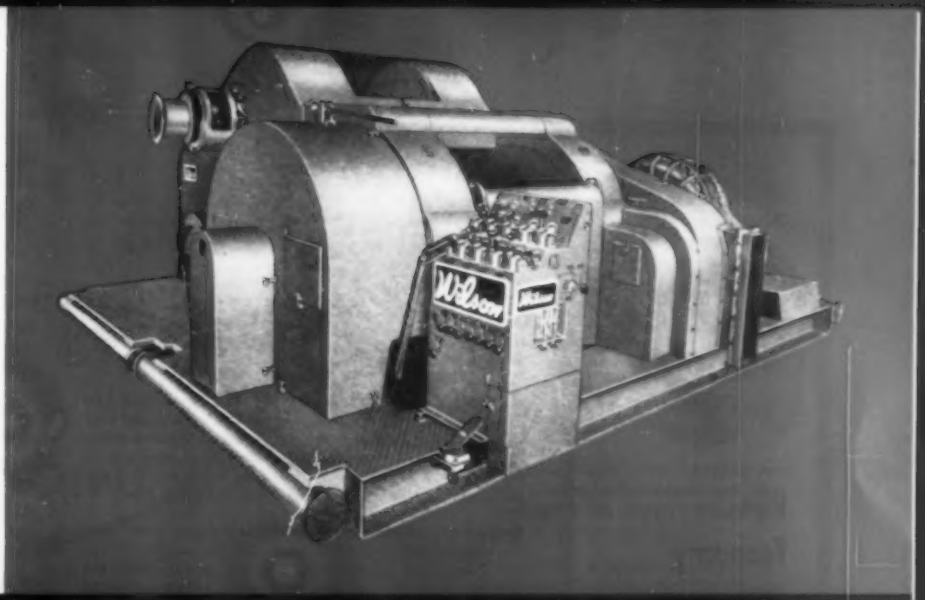

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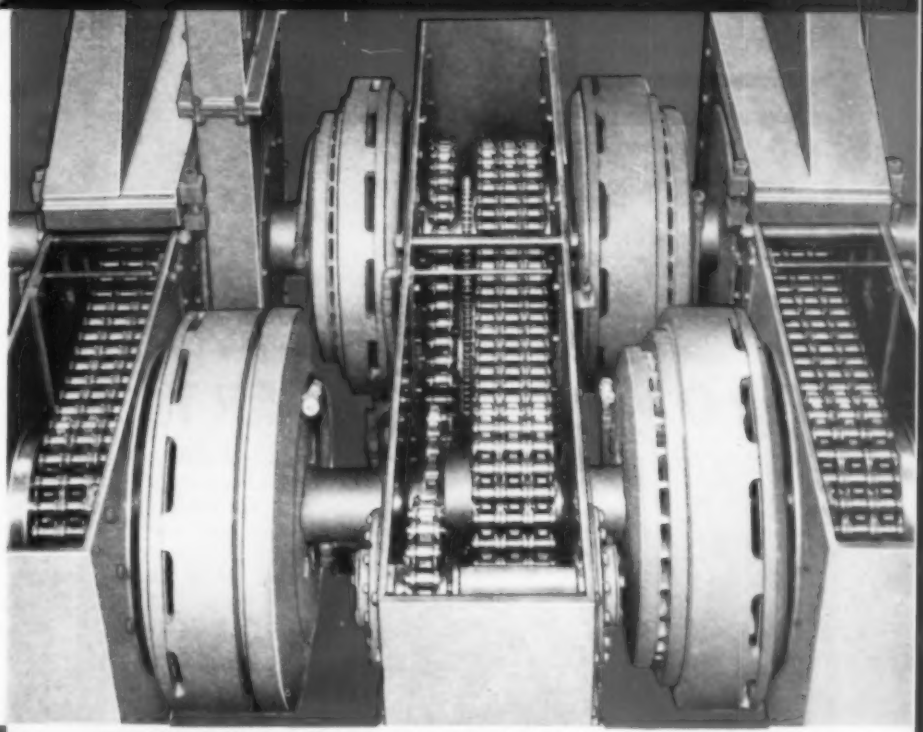

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Drilling

★ **Million-and-a-half dollars drilling** expenditure has been set by Three States Natural Gas Company, Dallas, Texas, during its 1957-58 fiscal year. This marked increase by a relatively small firm is the first indication of a better — instead of poorer — drilling year in the offing. Everett A. Jenkins, executive vice president of Three States, told stockholders recently that most of the money would be for development, with the bulk of the activity centered in the Aneth field area of southeast Utah. Three States will keep two rigs running and will drill no less than 16 wildcats in the Four Corners. The firm has extended its activity into Alaska through a recent filing for 100,000 acres in leases.

★ **Between 41,000 and 50,000 new wells** a year are needed just to maintain present oil production capacity in the U. S., says L. F. McCollum, president of Continental Oil Company and head of a National Petroleum Council committee on oil productivity. McCollum, in a report to H. W. Stewart, director of the oil and gas office of the Department of Interior, stated that the nation had ability to produce 9,867,000 bbl of crude daily in January 1957 and without drilling additional wells, the capacity would decline at the rate of 7.5 percent in the first year. It was indicated in the report that better production techniques could not be relied on to hold U.S. production to necessary levels without an adequate drilling program.

★ **Offshore drilling** in water depths up to 1000 ft or more may be possible by a new procedure developed and patented by the CUSS Group, consisting of Continental Oil Company, Union Oil Company, Shell Oil Company, and The Superior Oil Company. The system, for which U. S. patents have been issued, has widespread application in opening up vast new underwater areas for developing oil and other mineral resources beneath the ocean's surface. The CUSS Group, with Union Oil as operator, has already used the patented techniques successfully to drill over 300,000 ft of hole, some several miles off the California coast in water depths long believed impossible to explore. Holes have been drilled in water depths up to 1500 ft even though the comparatively small vessel containing the equipment rose, fell and swung about under the impact of high waves and strong ocean currents. In recent months an average of 450 ft a day has been drilled under such conditions. Basically, the system involves forming a base of operations at the bottom of the ocean connected to the ship floating on the surface by flexible guide cables.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Two-way Safety

FOR FISHING, TESTING AND DIAMOND CORING OPERATIONS...

THE SHAFFER Oil-Sealed JAR SAFETY JOINT

. . . a two-purpose tool — *Up-Jar* and *Safety Joint* — in which all operating parts are sealed in oil — permanently protected against mud, sand and corrosion! Here are the highlights:

The Shaffer Oil-Sealed Jar Safety Joint offers all the "two-tools-in-one" features—and the many other advantages of the original Jar Safety Joint first developed by Shaffer years ago. It can be used in testing, fishing, diamond coring or other operations to deliver a sharp upward blow for freeing the string whenever it becomes stuck . . . and, as a Safety Joint, can be readily released in the event the string cannot be loosened.

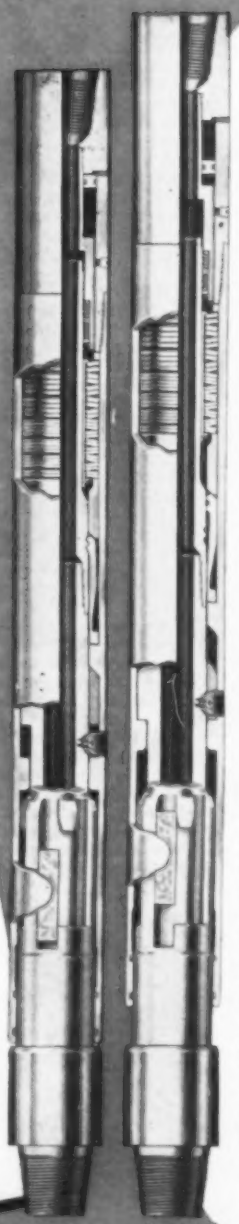
Both these operations—Jarring and Releasing—are performed under the positive control of the operator, and either action can be selected at his discretion.

MECHANISM COMPLETELY OIL-SEALED

To protect the mechanism against the corrosive and abrasive actions of mud, sand and grit, all operating parts are now sealed in a chamber filled with clean oil. At even the greatest depths and highest fluid pressures, this oil-filled chamber prevents the drilling mud from contacting the internal mechanism of the Jar Safety Joint because the oil in the chamber automatically "balances" the varying hydraulic pressures in the well so that packing units are not subjected to excessive pressure differentials.

Result . . .

1. **There is no change in "tonnage trip-off" or other characteristics as operating depths increase.**
2. **Abrasive mud, sand and grit—corrosive chemicals and salts—never contact the operating mechanism. This assures longer life, negligible maintenance.**
3. **The packing, not being subjected to excessive pressure differentials, lasts much longer and remains leak-proof at even great depths.**



SET POSITION — TRIPPED POSITION

Other important advantages

In addition to its Oil-Sealed design, these advantages are also typical of the Shaffer Oil-Sealed Jar Safety Joint . . .

- Jarring action is automatic and positive. To deliver a sharp upward blow, it is only necessary to raise the string until tension is equal to the pre-set tripping load of the tool, whereupon the blow is struck. Lowering the string again re-sets tool for another blow—and repeated blows can be struck as fast as the string can be raised and lowered.
- Only *straight pull* is necessary to operate the tool. No torque or other secondary operations are needed—particularly important on fishing, testing and similar strings where light connections are used.
- The force of the blow is absorbed by integral knocker heads built into the tool—not by easily-damaged drive-keys or threaded elements.
- The Shaffer Oil-Sealed Jar Safety Joint does not depend upon friction for its tripping action. Therefore the tool is not subject to variable operating characteristics. Its action is dependable, uniform, fool-proof!
- The Safety Joint portion has important advantages over conventional safety joints. No threads are used in the releasing mechanism—therefore there's no risk of overtightening by torque. Nor is there risk of accidental release by reverse rotation. Yet when simple releasing procedure is followed, *the tool releases with less than ¼ turn at the tool!*

There are many other advantages. Get the full story by sending for booklet at lower left.

Get The Complete Story on this important Shaffer advancement by sending for this 8 page descriptive booklet. It contains cutaway views of the tool showing the oil-sealed construction and explaining how the tool operates without depending upon friction for tripping . . . gives application details for the tool . . . full dimensions of the various tool sizes, together with exploded views of parts, etc. Or see our nearest Shaffer representative for details.

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FARMINGTON, NEW MEXICO, Shaffer Tool Works, Post Office Box 546
CASPER, WYOMING, Shaffer Tool Works, Post Office Box 1788
EXPORT SALES OFFICE: Shaffer Tool Works, 500 Fifth Avenue, New York, N. Y., U. S. A.

34 years OF OIL TOOL LEADERSHIP

RUNNING TOUR with MEN in the INDUSTRY

▸ **O. C. "Charlie" Clifford Jr.,** Atlantic Refining Company's chief geophysicist, has been elected president of the Society of Exploration Geophysicists. He will be installed November 11 in Dallas, during SEG's annual meeting.

▸ **Lee Daniel** has been elected vice president in charge of drilling and **Robert William Haigh** was elected financial vice president of White Eagle Oil Company, Tulsa.

Daniel has served as vice president of Helmerich & Payne, Inc., a wholly owned subsidiary and will continue to hold that office in addition to serving as vice president of Helmerich & Payne, C. A., a Venezuelan subsidiary. Reporting to Daniel from Venezuela is **Charles DeLay,** recently appointed general manager of that company. Named assistant to the president was **Daniel R. Toll,** previously serving as executive assistant. He also functions as vice president of Engineering-Construction Company, a subsidiary engaged in pipeline construction throughout the country.

▸ **Harry N. Stamper** has been named chief civil engineer for Humble Oil & Refining Company. He succeeds **S. W. Oberg,** who has retired after 29 years. **William A. Castille,** who was a division engineer in the Houston office, has been appointed assistant chief civil engineer, the position formerly held by Stamper.

H. N. Stamper

W. A. Castille

▸ Expansion of Latin American operations of Geophysical Service Inc. has prompted several appointments in supervisory personnel for that area.

G J. Kohler Jr. has been named manager of Latin American operations. Reporting to Kohler will be four regional operations managers. **Rodolfo Martin** will direct GSI operations in Mexico from Mexico City. **John Donna** is supervisor for the area. **C. J. Spivey** will remain in Caracas as manager of Venezuelan operations. **P. S. Stoutjesdyk,** in Rio de Janeiro, will manage Brazilian operations. **H. L. Heggy** and **P. E. Swensen** will be supervisors in Brazil. GSI's Andean operations will be managed from Lima, Peru, by **D. W. Rockwell,** with **Murrell Holbert** as supervisor in Bogota, Colombia.

▸ Realignment of Union Oil Company's Pacific Coast field department into three divisions by consolidation of the present Coast and Ventura divisions has been announced. Division superintendents will be: **J. T. Ledbetter,** southern; **C. E. Smith,** coast, and **J. L. Stair,** valley. **John R. Fraser,** present valley division superintendent, will become assistant manager of natural gas and gasoline operations. **R. G. Smith** and **R. T. Wheeler** will be assigned to secondary recovery projects. Under the realignment program Union's field engineering department **C. F. Bowden** will be chief petroleum engineer, and **A. F. Woodward** chief exploitation engineer. Division engineers will be **V. S. Moyer,** southern; **F. R. Wade,** coast; **C. A. Steiner,** valley.

▸ **Joseph J. Lawnick,** assistant chief petroleum engineer, La Gloria Oil and Gas Company, Corpus Christi, Texas, has resigned to become drilling and production superintendent, American Petrofina, Inc., Corpus Christi, Texas.

▸ **Arthur W. Winter,** Tucson, Arizona, has been elected controller of Great Northern Oil Company. He headed his own firm, Winter Distributing Company, Tucson, Arizona.

▸ **Richard C. Kerr,** consulting engineer to ARAMCO, has accepted the position of consulting engineer to Union Industrielle Africaine (UIA) of Algiers and Paris, and to Transportes Saharions (TRAS) Algiers, and their associated American company, Inter-Equipment, New York. He will retain his ARAMCO consulting post.

▸ **Arthur E. Dietert** has been named Cities Service Oil Company representative on the CATC Management Committee, with headquarters in Houston, Texas. Dietert recently returned from Italy where for several months he has been on special assignment for the company.

▸ **Waldo W. Neikirk** has been appointed assistant controller of Tidewater Oil Company. Prior to joining Tidewater, he served as treasurer and controller of the Dewey and Almy Chemical Company.

▸ **E. D. Anderson** has been promoted to superintendent of production in charge of Lone Star Producing Company personnel in the production department. **Jack Gourley,** as assistant chief engineer, will aid the chief engineer and supervise Lone Star Gas Company personnel and work pertaining to the department.

▸ Plans for the establishment of offices in Calgary, Alberta, Canada, and the appointment of **Herman A. Engel Jr.** as manager of Canadian operations have been announced by Union Oil and Gas Corporation of Louisiana. Engel joined Union Oil and Gas as senior engineer in 1951 and recently has been serving as technical assistant to the president.

H. A. Engel Jr.

L. F. Drake

▸ **L. F. Drake** has been appointed division manager of the Oklahoma division of Welex Jet Services, Inc. He will make his headquarters office in the company's division office in Tulsa. Drake formerly was assistant sales manager with offices in Fort Worth.

▸ **Don E. Stewart** has been named manager of Well Completions, Inc., engineering department. Prior to joining the Denver firm, Stewart was for 10 years connected with the Pan American Petroleum Corporation in their Tulsa research center.

▸ **Joseph Saxon Jr.,** most recently associated with Ryder Scott Company Petroleum Engineers, announces the formation of a new reservoir engineering consulting firm, Saxon Engineering, with offices in Wichita Falls, Texas.

▸ **Robert C. Hagens** has resigned as production superintendent, American Petrofina, Inc., Corpus Christi, Texas, to become drilling and production superintendent, Coloma Oil and Gas Company, Corpus Christi, Texas.

▸ **J. M. Evans,** assistant vice president, engineering, of Standard Oil Company of California retired on October 1 after completing more than 41 years of service.

AAODC Brass — Going, Staying, Coming. Past President of the American Association of Oilwell Drilling Contractors Jack Abernathy bows out to Brad Mills, executive secretary of the organization, and welcomes J. U. Teague as the new president. Teague, who will take office January 1, is president of Columbia Drilling Company in Houston. The trio is shown here at the recent AAODC Convention in Tulsa, Oklahoma, at the time of the election.

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YOUR PARKERSBURG DERRICK WITHSTOOD BETTER THAN 110 MPH WINDS AND WAS IN DIRECT PATH OF HURRICANE AUDREY WITH 8,000' OF 5" DRILL PIPE IN DERRICK AND SUFFERED NO DAMAGE WHATSOEVER TO DERRICK, SUBSTRUCTURE OR RIG EQUIPMENT.

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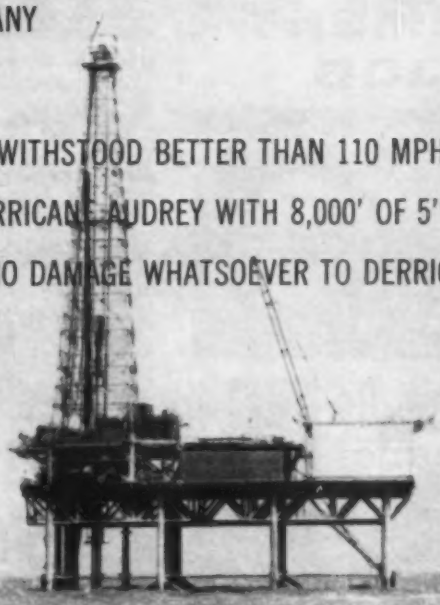

Hurricane Audrey vs. **Parkersburg Galemaster**

Hurricane Audrey found out what drilling rig owners have known for years — a Parkersburg Galemaster derrick is designed and built right for strength and durability. The most severe hurricane to rake the Gulf Coast since drilling rigs moved off-shore was unable to knock over the Galemaster derrick on the Gulf Marine Drilling Co. platform 20 miles off Cameron, Louisiana. Some derricks tumbled under the force of the wind but the Galemaster rode out the storm.

Get this added protection that only Parkersburg Galemaster derricks provide. There is a Galemaster in either a single well, two-well, or six-well design to suit your requirements. For gale insurance, buy a Parkersburg Galemaster derrick.

At Parkersburg, quality and service have gone hand-in-hand for 60 years!

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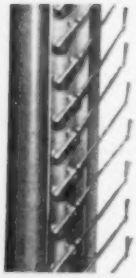

B and W Rotating Scratcher — Multi-Flex Type

Movement of Casing...

. . . equipped with B and W Centralizers and Scratchers (reciprocating or rotating), until the plug "bumps," provides the highest percentage of successful cement jobs.

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Running Tour

W. R. Lund has been named production manager of Shell Oil Company's New Orleans exploration and production area. He succeeds **J. W. Pittman,** who is on an extended leave of absence as a result of a serious automobile accident. Prior to his new assignment, Lund was area production manager in Calgary, Canada.

Charles W. Weeks has been appointed district geologist for South, Central, and northeastern Alberta, including the Tarsands area, for Sun Oil Company.

William W. Clawson, coordinator of domestic production for Socony Mobil Oil Company, Inc., will become a member of the Magnolia Petroleum Company management, with headquarters in Dallas, Texas, effective December 1. In his new position, he will be responsible for coordinating Magnolia's exploration and producing activities.

W. W. Clawson

E. W. Dissler

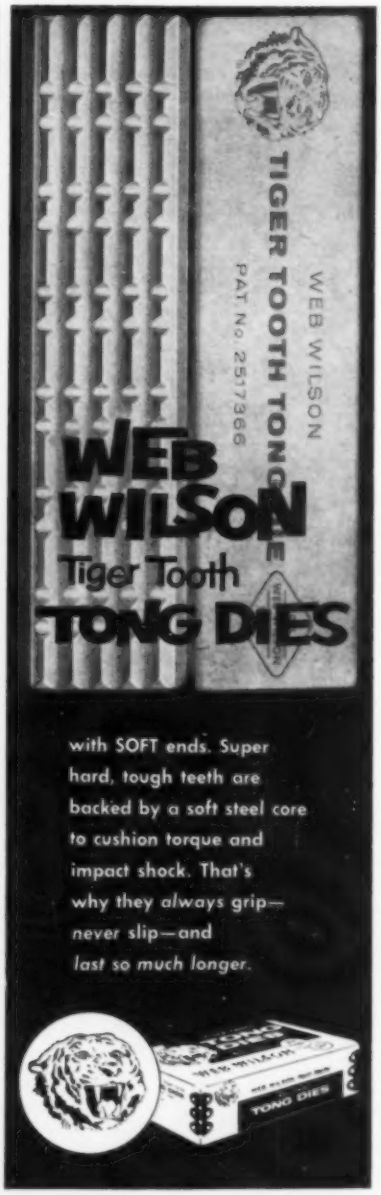
Promotions and transfers in the land and geological division of Cities Service Oil Company have been announced. **Murray G. Wells** becomes assistant chief geologist succeeding **E. W. Dissler,** who has been named a vice president of Canada-Cities Service Petroleum Corporation, Calgary. Wells, manager of exploration, Mid-Continent division in Bartlesville, is succeeded by **Barron Housel,** who has been assistant superintendent of the land department. **Mark Payton,** division landman for the Mid-Continent division, becomes assistant superintendent of the land department. Succeeding Payton is **Rex Tarr,** assistant division landman at Midland, Texas.

Wyatt Norman has joined Trunkline Gas Company, Houston, as district landman with headquarters in Corpus Christi, Texas. He formerly had served as manager of the land department of Reynolds Mining Company.

Harold D. Hoopman, former superintendent of uranium exploration in the Ohio Oil Company's Casper, Wyoming production division, is the new operations manager of the Ohio Oil Company of Guatemala. Hoopman will be in charge of all drilling and production of concessions held jointly by Ohio Oil of Guatemala and several other oil companies. **J. P. D'Artois** is the resident manager, headquartered in Guatemala City.

D. M. Simmons, with more than 36 years service with United Gas Corporation and predecessor companies, has retired. He was assistant general superintendent of drilling and production with headquarters at the general offices of United Gas in Shreveport.

Story J. Sloane Jr. has been named land manager of the Commonwealth Oil Company of Houston. Before joining Commonwealth, Sloane had been a landman for the Pan American Petroleum Corporation and its predecessor, Stanolind Oil & Gas Company.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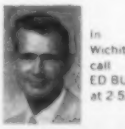
with SOFT ends. Super hard, tough teeth are backed by a soft steel core to cushion torque and impact shock. That's why they always grip—never slip—and last so much longer.
TONG DIES

In Shreveport, call E. E. TEDFORD at 7-1775

In New York, call HERB MALAND, Circle 6-0970



In Wichita Falls, call ED BURBANK at 2-5254

MERRICK PHELPS is the man at CApitol 7-0521, Houston

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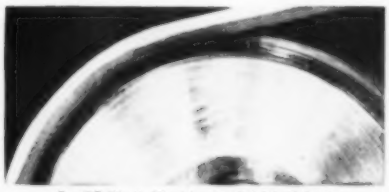
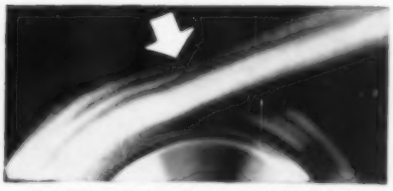
Here's what over 6 years' service in oil fields has shown about Morse Hy-Vo's unique features:

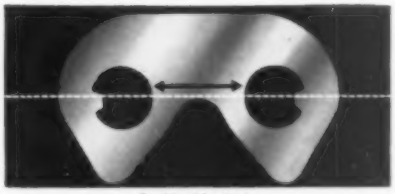
Exclusive Hy-Vo Joint



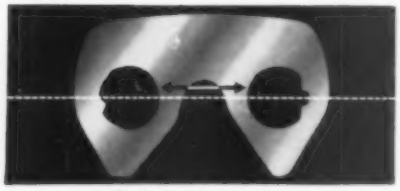
A. 2" Pitch Hy-Vo at 3600 F.P.M.



B. 2" Pitch Roller Chain at 3600 F.P.M.



A. Hy-Vo Link



B. Conventional Link

Exclusive Joint Design Ends "Freeze-Up" At High Speeds

Smooth, rolling action between pins eliminates sliding-joint wear. Reduced metal-to-metal contact prevents high-speed "freeze-up." Morse Hy-Vo runs ⅓ cooler than other chain drives.

Involute Teeth and Sprockets Give Smoother Power

Hy-Vo (A) is smooth as a belt at high speeds . . . prevents shock loading and stress that cause "humping" in roller chain (B). Permits use of heavier pitch chain, reduces width for a given load.

Stronger Links Provide Maximum Resistance to Fracturing

Thicker waist on Hy-Vo link (A) means that stresses are distributed across solid metal—not through crotch (B). This gives Morse Hy-Vo added protection against breaking at high speeds.

Morse Hy-Vo Drive gets *full* power from compact, high-speed diesels now being used in oil field applications. And it makes equipment more portable, less costly.

Contact your local Morse Distributor, headquarters for Hy-Vo sales and field service (he's listed in the Yellow Pages under "Power Transmission"). Or write: *MORSE CHAIN COMPANY, HOUSTON OR ODESSA, TEXAS; ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois.*

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REMEMBER: Only Morse offers you all four of these basic drives: Hy-Vo, Roller Chain, Silent Chain, and "Timing"* Belt.

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How McEvoy uses "CONTROLLED FRICTION" to prevent casing failures

Engineered into each McEvoy Casing Hanger is the exclusive "Controlled Friction" principle, developed by McEvoy to permit hanging of casing to its full joint coupling strength without damage to the casing. This principle is your assurance of maximum safety and economy.

McEvoy "CF" Casing Hangers securely grip the casing with sharp inner teeth while precision-made outer teeth control the slip bowl friction, automatically limiting downward movement of slips in the bowl. These casing hangers effectively solve the problem of reconciling high load capacity and good initial pipe bite by increasing the friction between slip and bowl as the casing load increases, stopping downward casing travel *before* the casing is damaged by the slips.

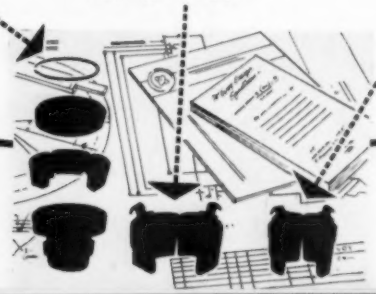
Hydraulic and mechanical loads are completely separated by use of two separate and independent support areas in these McEvoy Hangers. Pipe bottlenecking is completely eliminated and casing pressures, test pressures, or high pressure remedial work cannot load the slips or change their pipe load capacity.

McEvoy casing hangers for all wells

McEVOY "CB" CASING HANGER . . . designed for medium and medium-heavy casing strings . . . combines "Controlled Friction" slips and "Shielded Seal" pack-off with maximum economy . . . will safely hang casing to full short joint coupling strength.

McEVOY "CB-2" CASING HANGER . . . fits the space-saving, low-cost Type "C" Casing Head. Provides economical, medium duty, wrap-around, automatic set and seal service . . . may be wrapped around the pipe and dropped through the preventers to provide automatic sealing with very low pipe load and to safely support the pipe.

McEVOY SB-2 CASING HANGER . . . the complete answer to every deep, high pressure, heavy string need. May be wrapped around the pipe and dropped through the preventers for automatic set and seal . . . will safely support any casing string that can be picked up in the derrick.



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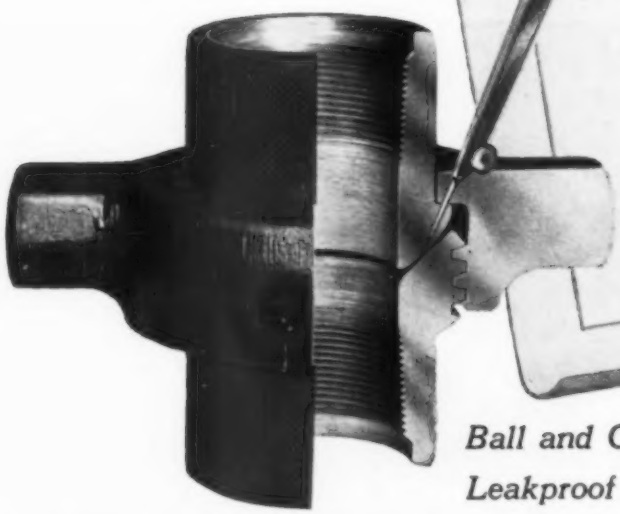

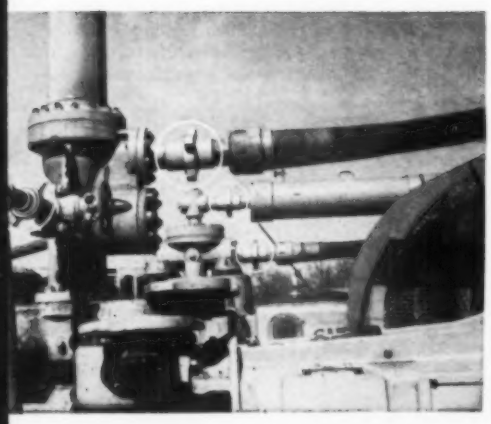

Ball and Cone Seat Design Provides Positive Leakproof Seal for High or Low Pressures.

For 23 years, WECO Unions have set the standard for the industry; have stayed out in front because of a fundamentally correct engineering principle—the ball and cone design that prevents leaks under high pressures, shock, surge or vibration.

With the spherical male part seated in a concentric circle in a mirror-finished conical female part, unequaled metal-to-metal sealing is obtained time after time, every time.

In addition, WECO Unions have stronger subs and wing nuts, heavier wall construction and sturdy Acme threads. Thus, they stand up on the toughest jobs, continue to operate with easy efficiency under extremes of pressures, volumes and abrasions.

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3 More New Rigs Get General Electric Drive for Land, Offshore Drilling

More and more rigs for both land and offshore applications are being specifically designed for electrified oil well drilling with General Electric drive systems. Here are just a few of the reasons why:

- Designed-in control simplicity of G-E drive eliminates complicated external apparatus, feed back systems, and torque limiting devices.
- General Electric drive gives you greatly increased flexibility. Fewer parts to service mean less maintenance time and expense.
- You can use General Electric drive with virtually any popular oil field engine. G-E drive is at least 85% efficient and helps eliminate mechanical drive losses.
- General Electric drive is available for a wide range of applications, including all normal drilling functions on land or offshore.

Like the operators of the three rigs described on your right, you, too, can obtain these benefits from a General Electric Drive System.

For more information, call your nearest General Electric Apparatus Sales Office or your International General Electric Sales Office. (Principal drilling offices in Dallas, Houston, New Orleans, Denver, Tulsa, and Los Angeles; Bogota, Maracaibo, Caracas, Buenos Aires, and New York.) General Electric Company, Locomotive and Car Equipment Department, Erie, Pa. 115-23

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1 **GREAT WESTERN RIG NO. 44,** equipped with a General Electric S-343 drilling rig package, is now drilling what may become the world's deepest hole for Phillips Petroleum Co. near Ft. Stockton, Texas.

2 **PENROD DRILLING COMPANY'S JIM WOODRUFF BARGE NO. 51,** designed to drill in 70 feet of open water. G-E B574 drive system includes five G-E generators and seven drilling motors.

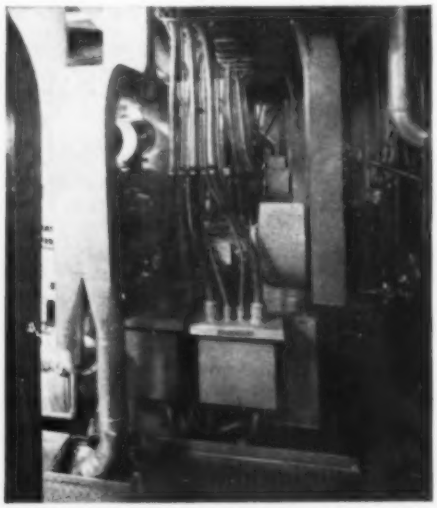
3 **CREOLE PETROLEUM BARGE NO. C228** is fitted with G-E drive components. Built to serve fixed or mobile platform, C228 has G-E B6743 drive system, White-Superior PTD-E8 diesels.

READY TO DRILL WITHIN 11½ DAYS, rapid rig-up was made possible by the portability of a G-E electric drive. Above, drawworks near derrick floor.

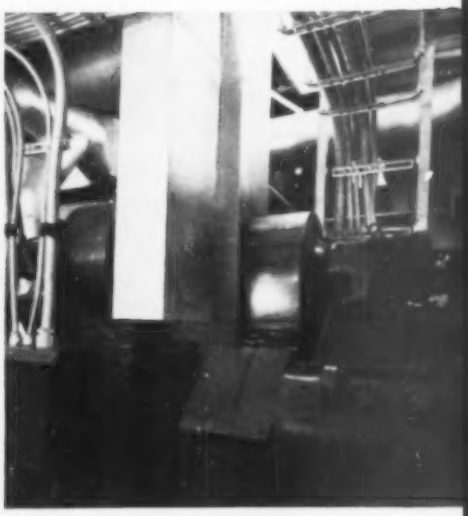
INCREASED FLEXIBILITY was gained with the use of G-E drive. Power skids with Cummins LRT-600 TURBODIESEL engines, G-E generators can be located "practically anywhere."

POWER CONNECTIONS ARE MADE QUICKLY with flexible cables, helping Great Western Drilling Company to speed operations.

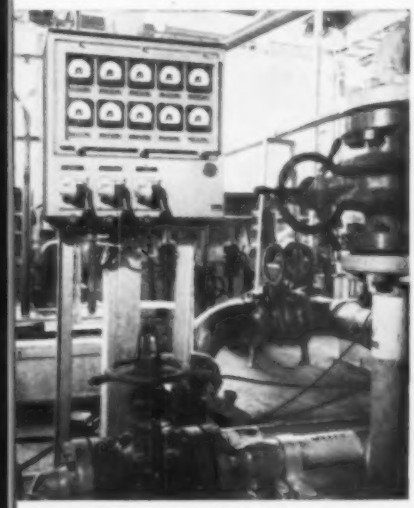
COMPACT G-E DRILLER'S CONSOLE gives operator better control of all electrically driven functions. Indicating ammeters, voltmeters are easy to read.



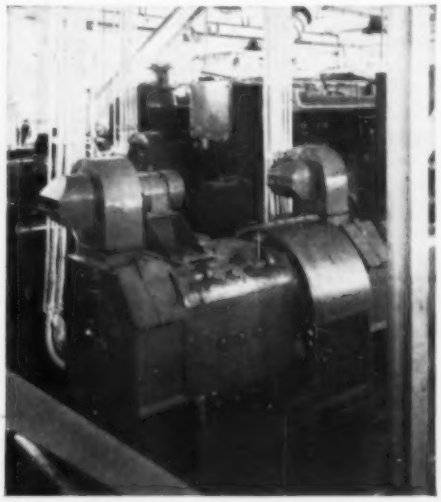
G-E 752J GENERATORS MATE PERFECTLY with Cat. D397 engines to produce reliable electrical power. Generators are reliable, easy to maintain, and have long life features.



EASIER EQUIPMENT SERVICING is made possible with G-E drive because power connections are flexible, can be easily broken.



FAMILIAR AIR THROTTLES mounted on General Electric-built pump room operator's console permit fast, accurate pump control.



COMPLICATED CONTROL DEVICES ARE ELIMINATED aboard Creole's C228. Six G-E 752 drilling generators and seven G-E 752H motors have "built-in" control, protection features.

CONTROL DEVICES ARE EASY TO SERVICE. Main d-c control cabinet has only simple contactors, relays, resistors and air valves.

In Venezuela....

Well Data Hard to Come By

Detailed subsurface information considered a valuable commodity; industry searches for basis of better exchange of data in specific areas

CURRENT well information in particular and subsurface information in general is difficult to obtain in Venezuela. New operators who have arrived on the scene recently, will view the above as a gross understatement and will declare that such information is virtually impossible to obtain.

State-side operators and home offices do not comprehend the fact until they are personally confronted with it.

'Commodity' Classification

In Venezuela, for years the well and subsurface data have been considered as a commodity of exchange and barter for obtaining equivalent information from competitors. Therefore, any laxness in secrecy is considered to impair the value of the commodity. For that reason many oil companies have been rigidly adamant in adhering to a policy of censorship unless the information considered for release will not prejudice their operations or future efforts at bidding for concessions.

Whenever releases are made to competitors, they are made on the basis of a signed bilateral exchange agreement which spells out exactly what items of factual data will be exchanged for what in return, how many copies each party will receive, and where the material will be delivered.

Occasionally some selected statistics or the candid detailed description of a developed oil field may appear in some technical publications. In most such cases the published information is not likely to weaken the position of the operating company. Drilling progress and total depths for most wells are exchanged among accredited company scouts. On rare occasions, some confidential data may leak out to the press.

Viewing the general secrecy with dismay, many newcomers ask, "Why?" and have received many different answers and conjectures in reply. Here follow a few of them. No pretention is made to justify, criticize or evaluate their importance.

Operator's Opinion

Longtime operators have generated considerable sentiment against free exchange because to do so would dissipate their investment in foresight, courageous pioneering, experience and know-how. Furthermore, by virtue of long time operations, they have gathered vastly more information than any newcomer could accumulate for a great number of years. The old time companies ask themselves, "Why should the long time operators gratuitously give their expensive accumulation of experience and information to newly arrived competitors?"

It is natural for operators who conduct widespread exploratory and wildcatting programs to wish to reserve their information in certain areas for their own use until after specific tracts have been granted as concessions. Inasmuch as the granting of concessions by the Venezuelan Government has been spasmodic and unpredictable, the combination of facts has contributed to prolonging the top secret classification of much data.

Home Office Feelings

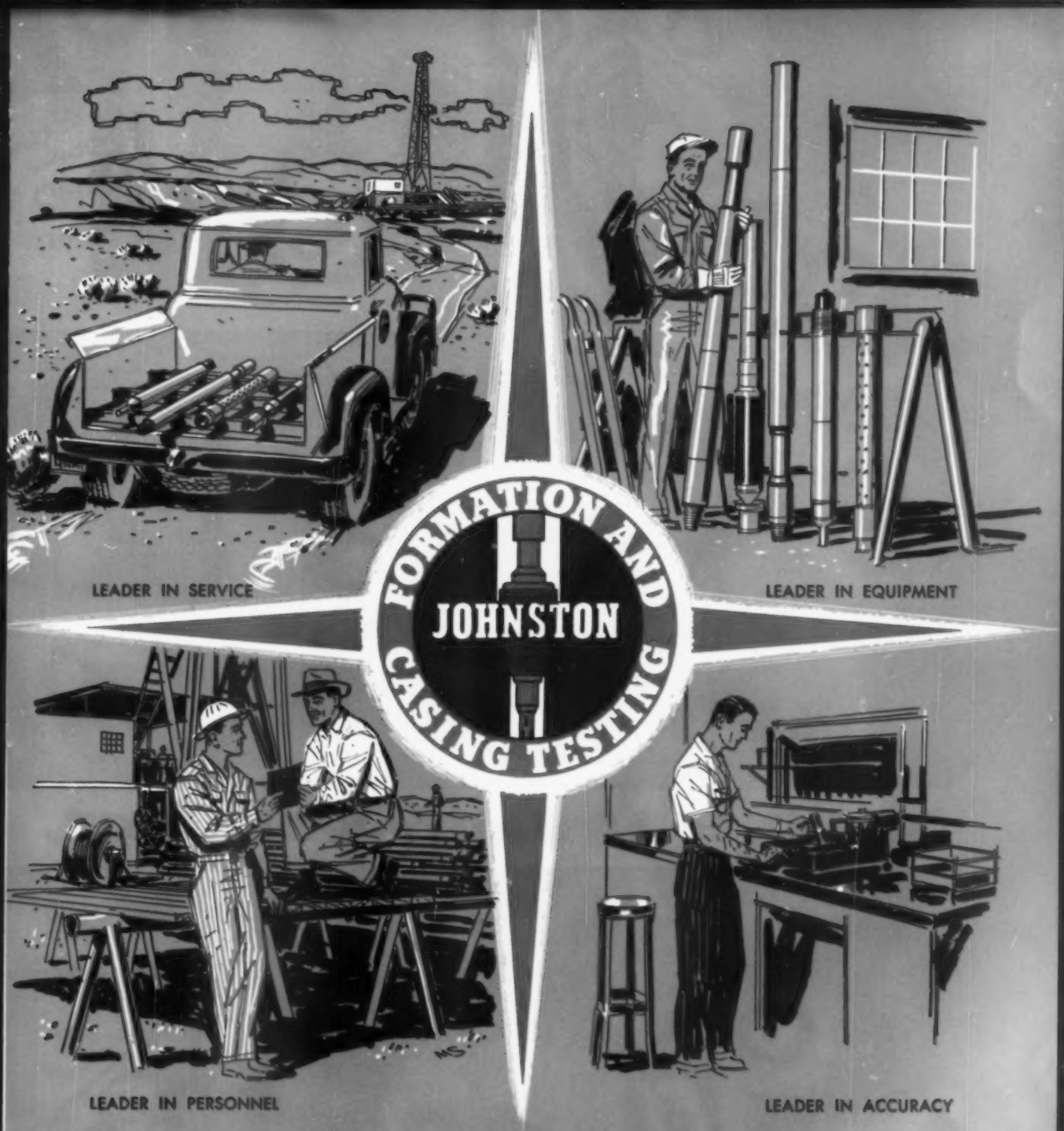
In some cases, a certain amount of reserve in free exchange of information is fostered by the home offices because they fear and wish to avoid the possibility of persecution by the U. S. Attorney General's office for collaborating to form a cartel.

It is also a fact that any policy of limited secrecy breeds more secrecy. In many cases, information is maintained confidential as a matter of long standing policy, although the purpose and limitations of the original policy have long since been forgotten, and the reasons quite possibly no longer exist.

Several unsuccessful attempts have been made among operators to develop free exchange agreements for specific areas. Negotiations fell through because operators whose holdings were limited to a small area under consideration probably felt that they would lose their commodity of exchange for information in other areas beyond the limits of the small proposed free exchange zone.

Industry Is Receptive

One thing is certain. The industry is receptive to considering an acceptable formula providing for freer exchange. However, established companies will want to study the matter carefully in the light of past experience before arriving at a decision one way or the other. ★ ★ ★



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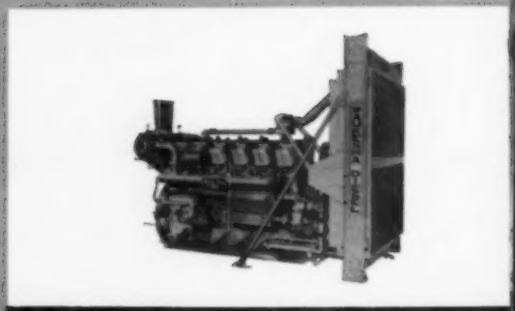

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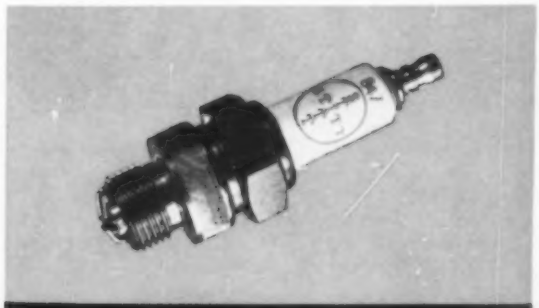
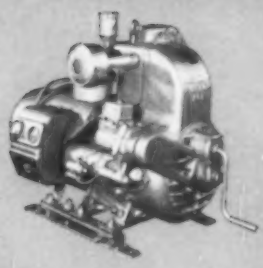
KOHLER **KOHLER** Electric Plants and Air-Cooled Engines provide an independent source of electric power capable of performing hundreds of routine jobs as well as providing essential standby protection against power failure. 500 watts to 30 kw.



STITT Industrial Spark Plugs are designed for continuous heavy-duty service. Massive center electrodes, three wide ground wires and extra-heavy construction, with modern, aluminum oxide insulators, make for economy and long life.

MARINE PRODUCTS Pumps—MP Straight Centrifugal Pumps for general applications, Flomax Self-Priming Centrifugal Pumps and Duraflex Rotary Pumps.



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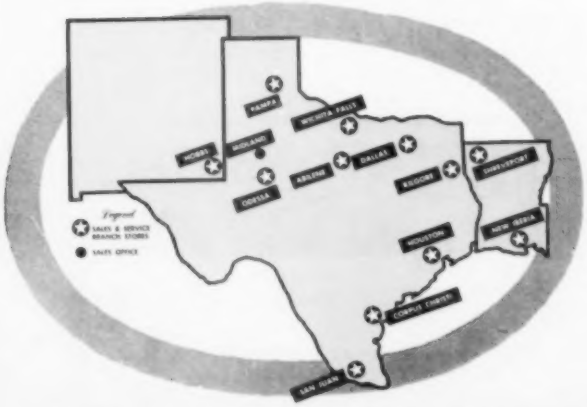
Inc. COVERS A LOT OF GROUND

From the Permian Basin to the coastal flats, Waukesha Sales & Service, Inc. is ready to serve you, around the clock. With twelve service points serving a four-state area, your engine is never more than a few hours away. And when you send your engine "home" to Waukesha Sales & Service, Inc. you are assured of **genuine** Waukesha parts and other name brand equipment, plus expert workmanship.

WAUKESHA SALES & SERVICE, INC. supplies dependable power for every need: drilling, pumping, hoisting, lighting, transportation. Our expert, personalized service keeps this power in tip-top shape.



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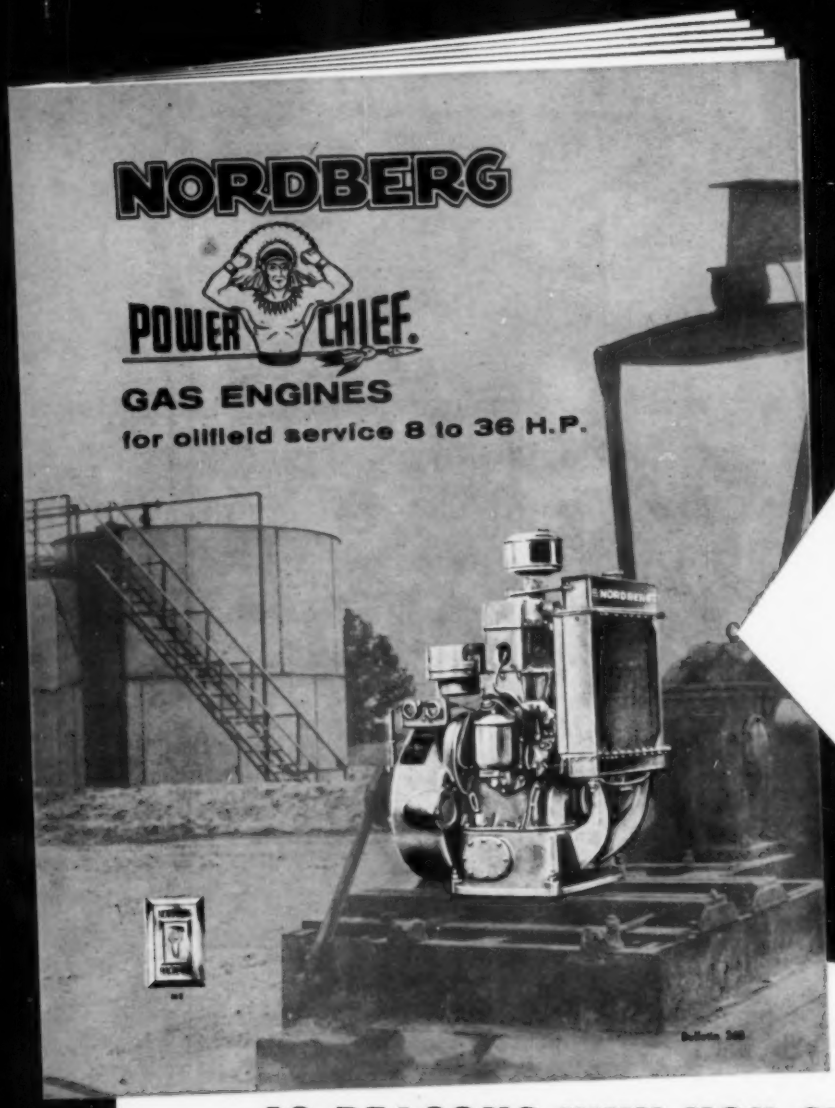
WORLD'S LARGEST DISTRIBUTOR OF OIL FIELD ENGINES



10 REASONS WHY YOU SHOULD USE NORDBERG *POWER-CHIEF*® OIL FIELD ENGINES

Throughout the oilfields, Nordberg Power Chief Gas engines are consistently compiling records for reliability and low maintenance costs . . . records that in many cases show more than 40,000 hours of continuous operation with original rings, valves, liners, bearings, piston and crankshaft still in place.

Listed at the right are 10 of the reasons behind the outstanding performance of Power Chief Gas engines in 'round-the-clock oilfield service. For the *complete* story, send for your copy of the all-new Bulletin 268 illustrated above.

1. CONSERVATIVE RATINGS
2. OPERATE ON SOUR GAS
3. SMOOTH, STEADY OPERATION
4. WEATHERPROOF
5. SAFEST ENGINE IN THE FIELD
6. EASY STARTING
7. MORE "EXTRAS" AS STANDARD EQUIPMENT
8. EASY TO SERVICE
9. PARTS AND SERVICE READILY AVAILABLE
10. QUALITY CONSTRUCTION THROUGHOUT

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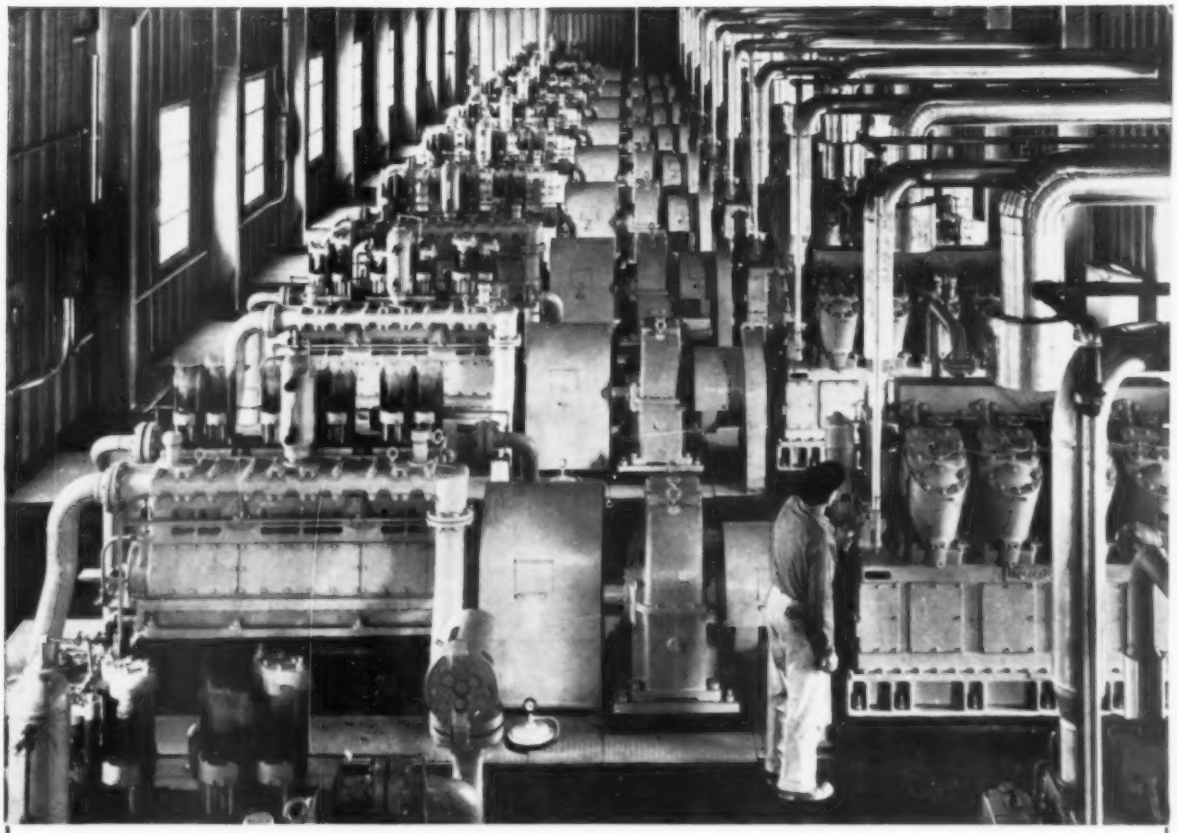


FIELD REPORT

FLOOD: North Ward-Estes Unit

PUMPS: 10 Aldrich Septuplex

FLOODING STARTED: December 1954

EXPERIENCE TO DATE:

Pumps operate constantly — 168 hours per week. There have been no breakdowns ... customer reports installation highly satisfactory ... "Maintenance actually has been less than we expected."

Field parts stock available in Carmi, Ill., Charleston, W. Va., Houston, Los Angeles, Odessa and Tulsa. For further information, write the Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

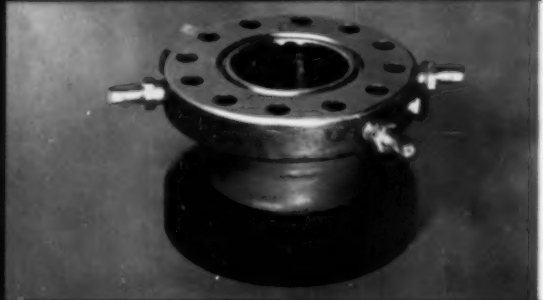
the toughest pumping problems go to ALDRICH

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

CAMERON PARALLEL MULTIPLE COMPLETIONS

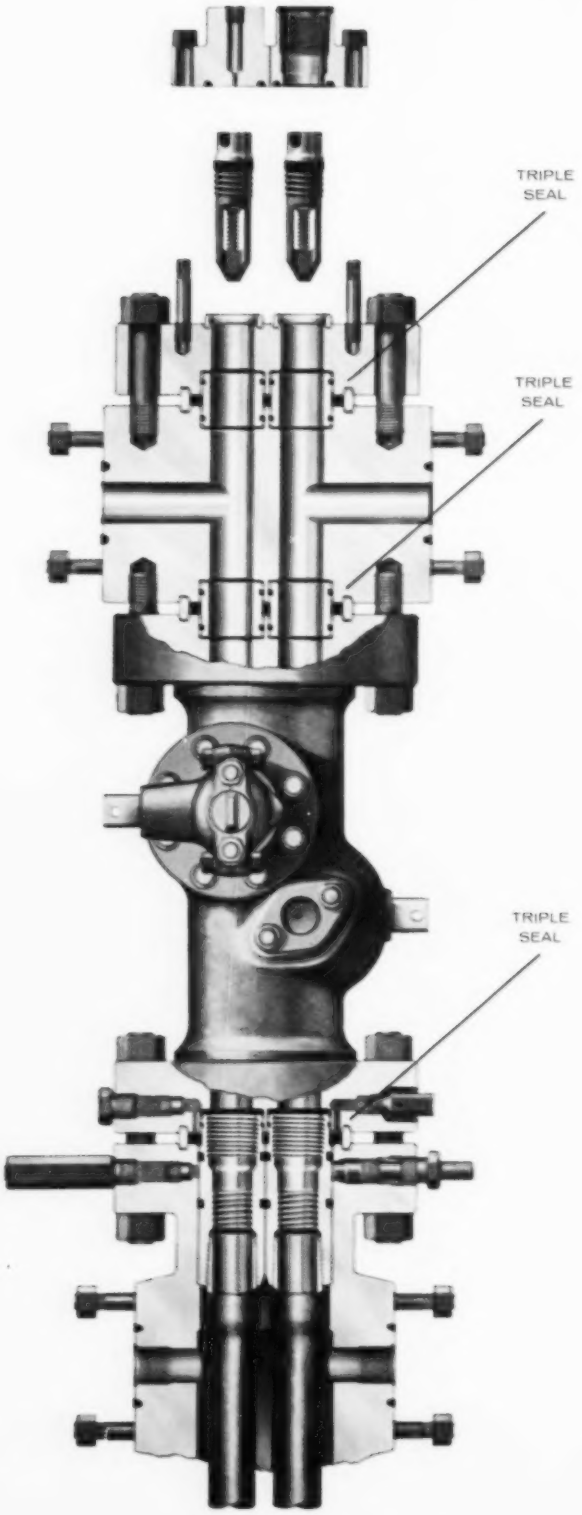
Easy Installation – Extra Safety and Economy

Check this series of illustrations to see why Cameron dual and triple completion trees afford advantages which are making them more popular every month. If multiple completions are possible Cameron will make them safer – more profitable with these versatile triple-sealed components.



1. Standard API tubing head spools will receive this short "DC-B" hanger spool to convert an existing well to dual completion. All spools are Cameron forged steel.

2. "DC-B" tubing head spool with side outlets. Notice the plastic injection guns and hold-down screws which securely lock hangers in tubing head before blowout preventers are removed.



The famous Cameron Closed-Pressure completion method makes Cameron multiple completions the safest in the industry. Cameron patented back pressure valves are installed and removed mechanically by use of polished rods.

3. The Cameron "TC" triple completion spool provides all of the same features as the "DC-B" dual spools — tubing strings may be run independently or together for any bottom hole operation.

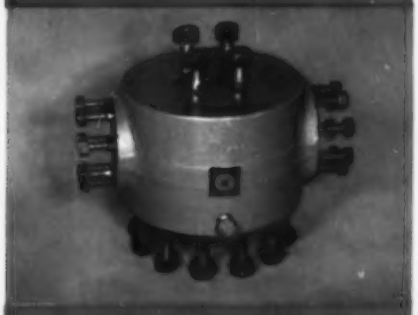
4. "DC-B" and "TC" Hangers locate automatically — may be run or pulled together or separately. They support full tubing joint strength — annulus pressures to full working pressure of tubing head.

5. Rugged oil resistant rubber seals are backed by steel rings on hanger necks and subs — are energized by injected plastic packing on annulus seals and circular pad.

6. Cameron Self-Sealing Ring Gasket shown in section eliminates the headaches and hazards of old style API rings. With rubber seals it forms a triple safeguard against leaks.

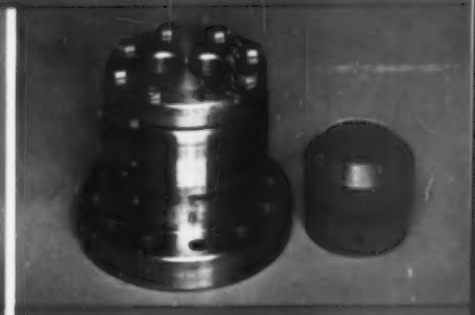
7. Cameron back pressure valves are the same size as the run of the tree. A 2" back pressure valve may be pulled through a 2" master valve making possible the famous Cameron Closed-Pressure completion.

8. Cameron dual bore Lift Plug master valve — easy operating — requires no lubricant for a perfect seal. Plug and seat can be replaced without removing valve from tree.



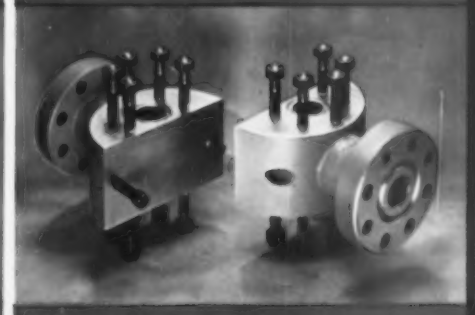
9. Forged steel dual bore tee with studded side outlets. Dual tee, seal flange and crown valve are all available with plastic injection ports or test ports optional in bottom flange.

10. Seal flange adapts from dual bore tee to individual caps. Permits optional installation of crown valve — triple sealed for safety.



11. Dual "QD" slip and seal assembly for low pressure flowing wells or pumpers. Dual "RFA" wrap-around tubing hanger is designed for use in Type "F" tubing head spool with a short "DC-B" hanger spool above.

12. Single tubing hanger for converting dual to single completion. "DC-FBB" ball weevil for threaded suspension. Wrap-around "RFC" allows full joint manipulation, keeps high bottom hole pressures out of the annulus.



13. This dual Split-Tee affords an economical solution for higher working pressures (to 5,000 psi) with independent master valves and flanged connections.

REMEMBER . . .

Cameron is the pioneer in multiple completions. Low pressure or high, deep or shallow, Cameron has the equipment and know-how for safe, economical, profit-making complete completions.

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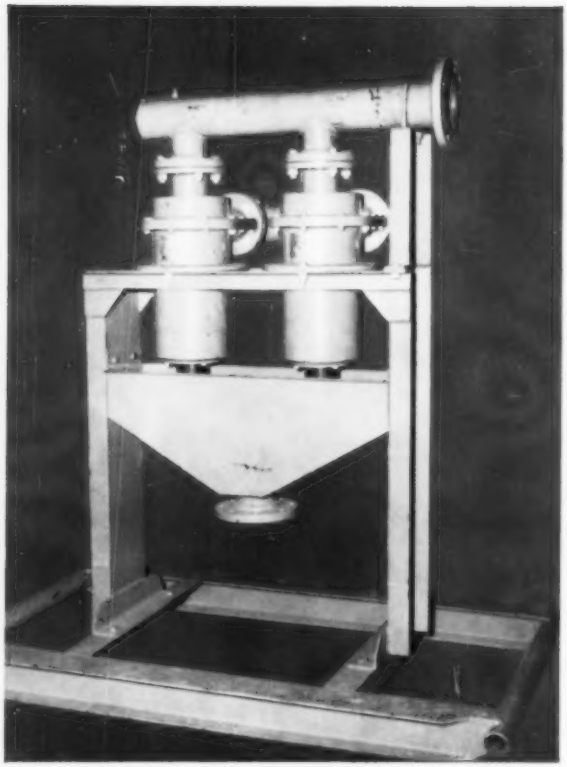
HERE IT IS...
a new 2-DorrClone
Dorrco
D-Sander

—designed especially for hard formation drilling



The new Size 2 Dorrco D-Sander is low in both first cost and operating cost. In addition, it is light in weight and easy to move. Designed especially for hard formation drilling with any rig, or slim hole drilling in a wide variety of formations, it brings the benefits of drilling fluids substantially free of drilled solids within the reach of every operator.

The benefits from using Dorrco D-Sanders are many. In many fields along the Gulf Coast, as well as other areas, abrasive sand can seriously reduce the life of bits and pump parts unless a D-Sander is used. In addition, the high viscosity of mud laden with drilled solids reduces drilling rates as much as 25 per cent.

In these areas, important savings in drilling costs result in that section of the hole where unweighted mud can be used.

But recent experience has proved that savings can also be realized in many other areas where abrasive formations are not encountered. In these areas, "flour sand" Dorrco D-Sanders, set to remove all drilled solids above 30 microns in size, result in greatly improved drilling speeds—sometimes in excess of 15 per cent.

In harder formations, drilling rates are slower and drilled solids are produced at a lower rate. In many of these areas, the Size 2 D-Sander, which provides capacities up to 250 gpm, is entirely adequate, yet it costs less to buy, to move and to operate than larger units.

The new Size 2 D-Sander compliments the capacity ranges of the larger sizes 4 and 6. With this new addition, Swaco offers units suitable for any rig and any drilling condition. Write for full information.

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❹ The PH-125 N/N log obtained in cased hole shows *less influence* from variations in casing position within the bore hole than do most other neutron logs.

❺ In bore holes not containing liquid, the PH-125 N/N log *retains* its high sensitivity to formation porosity where other neutron logs have little or no sensitivity and, in some cases, even reverse in their response to porosity.

❻ *In contrast to the definite effects which chemicals cause on other type neutron logs, the effect of saline fluids on the PH-125 N/N log is negligible for all practical purposes.*

There are many additional factors, but these are the six main reasons why PGAC's new PH-125 N/N log permits the *most accurate evaluation* of formation porosities possible today. Mail the coupon now for your 2 Free Handbooks. Get all the facts—and you'll always insist on the PH-125.

Clip This Coupon NOW And See For Yourself!

Sure, it will take a moment, and a stamp or postcard to mail it —but you'll be well rewarded!

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Please mail your 2 Free Handbooks on the new PH-125 Neutron/Neutron Log: ("Porosity Evaluation Charts for PH-125 Logs" and "These Charts Speed Porosity Evaluation of Radiation Logs.")

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NEW Drilling and Producing Equipment

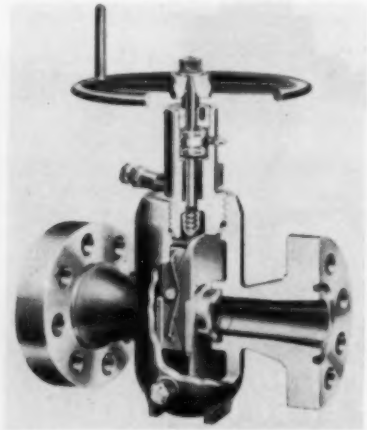
New 500-Ton Swivel. A 500-ton swivel, the Tru-Line 500, has been announced by Ideco, Inc. The Tru-Line 500 swivel, designed for the deepest, most severe drilling conditions yet encountered, utilizes 4 separate bearings for smooth, efficient, long-life operation.

The addition of a separate ball upthrust bearing relieves the alignment bearings of any extra duties so that they maintain true alignment even during severe drilling conditions and when the swivel is put into the rathole. The main bearing of the Tru-Line 500 swivel is a heavy-duty Timken tapered-roller type which supports the weight of the drill string.

Four sizes of Ideco swivels are now available with the addition of the Tru-Line 500: 150-ton, 250-ton, 300-ton and 500-ton. *Ideco, Inc.*

Circle number (1) on reply card.

2-In. Port Valve. The 2-in. reduced port valve is designed for use of Christmas tree wing installations. The valve is available in API working pressure of 5000 psi.



It has the same basic features as have all the firm's through-conduit production valves including pressure seal bonnet, parallel expanding gates, 2 roller-thrust bearings, closed packing box and superfinished stem. *W-K-M, Division of ACF Industries, Inc.*

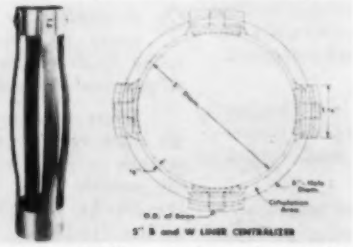
Circle number (2) on reply card.

Strain Gages. New SR-4 foil-type rosette strain gages with substantially higher sensitivity and stability than any previous rosette gage have been announced by the Electronics and Instrumentation Division. These gages are of bonded filament type construction. The rosettes have a sensitivity that is 8 percent higher than that of any previous rosettes. They need no lateral corrections, except in the most precise testing problems, can withstand temperatures as high as 300 F in continuous service and are thinner, more flexible and more easily applied than bonded wire SR-4 strain gages.

Two sizes of bakelite bonded rosettes are available: Types FABR-2 and FABR-4, with gage lengths of ½ and ¼-in. FABR-2 replaces the epoxy-backed rosette Type FAR-2, the foil gage formerly offered. FABR-4 is an entirely new product. *Electronics & Instrumentation Division, Baldwin-Lima-Hamilton Corporation.*

Circle number (3) on reply card.

Liner Centralizer. Centering is an important factor is lessening friction in holes of reduced clearance to successfully run liners to bottom. The new B and W liner centralizer meets this requirement with a combination of strength, streamlined construction, maximum circulation area, and a means of positive attachment, without welding, to the casing. This increased circulation area is provided by a lower, integral stop collar of special design.



Successful liner running and cementing techniques have proved the importance of: an effective centralizer, displaced circulation provided by a standard float, and a properly supervised lowering rate. *B and W, Inc.*

Circle number (4) on reply card.

Liquid Lockwasher. Jacobson Nut Manufacturing is currently manufacturing a new type of locknut with a liquid lockwasher. These nuts are treated with the new revolutionary "Loctite" sealant, which provides a high locking torque, at about ½ the cost of ordinary locknuts. These "Loctite" Locknuts are available in steel, aluminum and stainless, in a wide range of commercial sizes. *Jacobson Nut Manufacturing Corporation.*

Circle number (5) on reply card.

Ground Detector and Alarm. The PRD-C5700 ground detector is an electrical device with visual and audible alarms that indicate ground faults before they can do any damage. It can be set to discover a line voltage drop as little as 1 v in systems of any voltage rating.

The PRD ground detector operates at 110 v and can be installed at any control point. Transformers are included to operate it off the power line and one unit will take care of all equipment on 1 system. *Principle Research and Development Co.*

Circle number (6) on reply card.

Offshore Well Tester. New unit that is easily transported by service boat or barge to offshore installations and equipped with a special heavy duty lifting mechanism to facilitate movement from barge to platform has been developed by Rolo Manufacturing Company.

Another outstanding feature is a methyl alcohol injection system for injecting a hydrate inhibitor upstream of the inlet choke. For testing production of offshore oil and gas wells, skid-mounted well-checkers have been put into service offshore from Louisiana and are available on a rental basis. Unit separates and meters oil, water and gas, operating through working pressure of 1200 lb per sq in. *Rolo Manufacturing Company.*

Circle number (7) on reply card.

New Tubing Stop. A tubing stop for wire line has been announced by the Harold Brown Company. This stop features a design with large by-pass area—in 2 in. tubing it is equivalent to 1 in. opening and in 2½ in. tubing it is equivalent to 1¼ in. opening. The specially designed slips will support shock loads up to 100,000 lb. Positive hold-down on slips insures maximum running speed without prematurely setting the slips. The hold-down is released by jarring down. *Harold Brown Company.*

Circle number (8) on reply card.

New Backhoe. The model WR-350 backhoe, for mounting on International-Harvester 300-350 utility tractors, has just been announced by the Wain-Roy Corporation. A digging range of 190 deg, a digging depth of 12 ft below grade, and loading height of 9 ft combine to make this backhoe a flexible, versatile attachment engineered to operate profitably under the most cramped conditions.

A new and unique link-lever swing system provides extra smooth cushioned swing. The hoe is a complete self-contained unit and can be quickly and easily attached or detached – 4-pin mounting, 2 hose connections. *Wain-Roy Corporation.*

Circle number (9) on reply card.

Oilfield Floats. A complete new line of oilfield floats to meet the various requirements of the heavy machinery hauler has been introduced by Dorsey Trailers. Each is designed from the ground up for its particular capacity and length: the main beams and side frames for each model are engineered to give maximum strength with minimum weight for the operator's purpose.

The Dorsey Model LOFT-187 has the light weight and utility characteristics of a standard platform-type trailer. It is designed to haul evenly-distributed loads of 45,000 lb or up to 25,000 lb concentrated in 10 ft. The Model MOFT-187 medium duty oilfield float is designed for evenly-distributed loads of 60,000 lb or up to 41,000 lb concentrated in approximately 10 ft. Both the light and medium oilfield floats feature a special fabricated rear bumper with a 3-in. winch pipe step designed to conform with oilfield hauling requirements. The Dorsey HOFT-187, heavy duty oilfield float is designed for evenly-distributed loads up to 80,000 lb or up to 50,000 concentrated in 10 ft. An 8 in. extra-strong pipe tail roller is standard. *Dorsey Trailers, Inc.*

Circle number (10) on reply card.

Unit Goes to Alaska. The Payne non-separator type accumulator unit, one of the largest ever built, is going to Alaska for service on a major oil company rig. It consists of 2 automatically controlled heavy duty Payne pumps, 4 Payne 20-gal non-separator type accumulators which operate without diaphragms or bladders, and four 11 cu ft air receivers with a 5 hp compressor. A remote control manifold for Hydril preventers is included. Bearings are specially sealed and lubricated for extreme low temperature operation. *Payne Manufacturing Company.*

Circle number (11) on reply card.

Insulation Cover for Tanks. A new way of economically insulating stationary and portable storage tanks utilizes corrugated steel roll roofing as the insulation cover. The covering, Cecoroll, provides a low-cost, durable, attractive and easily-maintained covering for the tanks.

Starting from one end of the tank, strips of fiberglass aerocor insulating material are first placed directly upon the tank in thicknesses of 2 to 4 in., depending upon the amount of insulation desired. Cecoroll is then wrapped loosely around the insulating material and held temporarily with steel bands. Rigid 2 x 2 spacers, formed of pieces of fiberglass roof insulation 4 ft long, are placed beneath the insulation so the covering will not unduly compress the aerocor insula-

tion. The Cecoroll is then pulled tight with the steel strapping, the ends of the Ceroroll joining at the bottom side of the tank. The edge of the Cecoroll is lapped over on the edge of the preceding section and secured with sheet metal screws through the lap. Because of Cecoroll's crimped edges it is not necessary to match corrugations when lapping. The crimped edges nest neatly and, therefore, it is easy to screw the pieces together. *Ceco Steel Products Corporation.*

Circle number (12) on reply card.

Over-Running Clutch Assembly. The development of a new centrifugally operated over-running clutch assembly has been announced by Eclipse Machine, division of Bendix Aviation Coporation. The unique clutch features a minimum amount of over-running friction due to the centrifugal action.

Bendix cited the following advantages of the unit, which can be built for any torque capacity: lower cost due to improved design; substantially smaller space requirements; minimum lubricating problems with many designs requiring no lubrication; less over-running torque; and less limitations to over-run speed. *Eclipse Machine Division, Bendix Aviation Corporation.*

Circle number (13) on reply card.

Diesel-Powered, Truck-Mounted Rotary Drill. A new, diesel-powered, truck-mounted rotary drill that makes hole faster and lowers costs has been announced by Schramm, Inc. Costs are lowered because, under constant drilling operations, fuel consumption is reduced as much as 70 percent in comparison with units employing a compressor driven by the truck's gasoline engine.

This unit makes hole 600 to 700 percent faster than is possible with the best churn drilling techniques. The diesel engine, an International Harvester UD 1091, is direct-coupled to a Schramm air compressor with no connection to the truck engine.

For long-distance highway transportation, the mast is lowered, but the rig can be moved around quarries or other installations with the mast up. Raised and lowered by hydraulic cylinders, the mast is made of heavy structural steel. It is 30 ft high, with 25 ft travel for 20 ft 6 in. drill pipe. *Schramm, Inc.*

Circle number (14) on reply card.

System for Changing from Low to High Btu Gas. For gas engine installations in sewage plants, drilling rigs, etc., where the Btu value of the fuel gas varies, Ensign has perfected and patented a new automatic system for changing from low to high and from high to low Btu fuels. The dual-fuel system is ideal for automatically switching from natural gas to LP-gas or vice versa. The installation consists of 2 fuel regulators. *Ensign Carburetor Co.*

Circle number (15) on reply card.

Power Transmission Belt. A new type of power transmission belt, Extremultus, has been developed. The principal features of the belt are as follows: It will not slip or stretch; it will operate at speeds up to 24,000 ft a minute and horsepowers up to 6000; it will deliver smooth constant speed at low tensions and at relatively slow speeds; it will operate at ratios up to 20:1 and arcs of contact as low as 90 deg; it will operate efficiently under shock loads up to 7 times the normal running loads; it will reduce the bearing loads; it will permit machine designers greater freedom in producing more compact and efficient designs. *Extremultus, Inc.*

Circle number (16) on reply card.

Continuous Cable Clamp. This new fitting available from Sauerman Bros. provides a quick way of attaching a load to a continuous cable. The clamp is being used for any job where a load must be connected to a line. The 3-part fitting consists of a wedge clamp, wedge, and cable clip. The continuous cable clamps are manufactured for rope sizes from $\frac{3}{8}$ to $1\frac{1}{4}$ in. *Sauerman Bros., Inc.*

Circle number (17) on reply card.

Pull Trailers. Production of a new line of pull and semi-trailers, completely redesigned, has been announced by Hobbs Trailers. Many suggestions and preferences of truck and pull trailer operators were included in redesigning the equipment for standard production. The result is a sturdy, lighter weight unit that can be put to a variety of profitable hauling chores. *Hobbs Trailer.*

Circle number (18) on reply card.

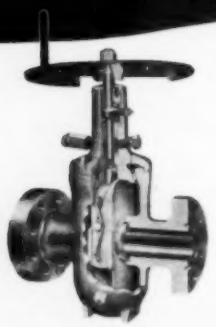
Special Purpose Analog Computer. A table top special purpose analog computer, designed primarily to solve office and factory business production problems, and which can be operated by the average clerical worker after only 8 hours instruction, is available from General Electric Company.

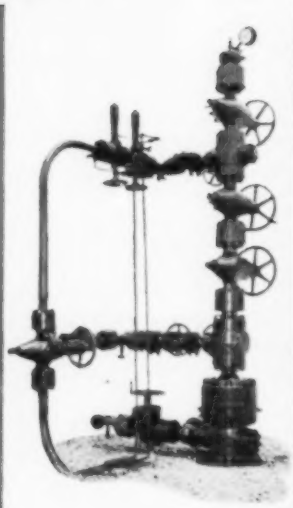
The computer can be used for any type of problem which requires the multiplication of 2 numbers and the summing of the results. Answers can be obtained within a matter of minutes so that corrective action can be taken almost immediately.

The unit is simple to operate; dials are set according to data at hand and appropriate signal buttons are pushed to arrive at the answer. No special installation is required and the computer can be plugged into any 115 v ac power outlet. *General Electric Company.*

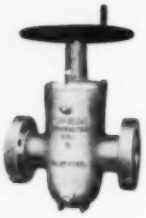
Circle number (19) on reply card.

W-K-M® THROUGH



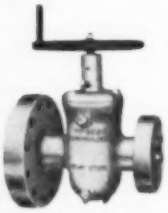


Screw-End Valves
Size: 2"
500 lbs. and 800 lbs. Working Pressure

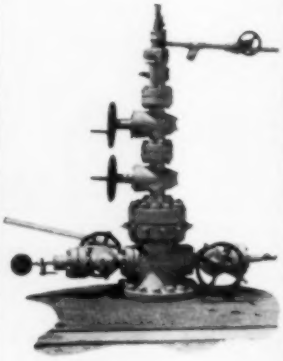


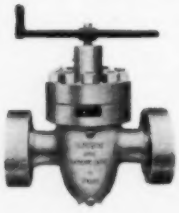
Flanged Valves
Sizes: 2", 2½", 3" and 4"
1000 lbs. thru 5000 lbs. Working Pressure

Screw by Flange Valves
Sizes: 2", 2½", 3" and 4"
1000 lbs. thru 5000 lbs. Working Pressure



Unequal Flange Valves
Sizes: 2", 2½" 3" and 4'
1000 lbs. thru 5000 lbs. Working Pressure

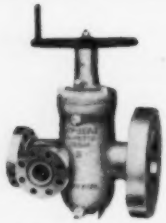




Bolted Bonnet Valves
Size: 4"
10,000 lbs. Working Pressure

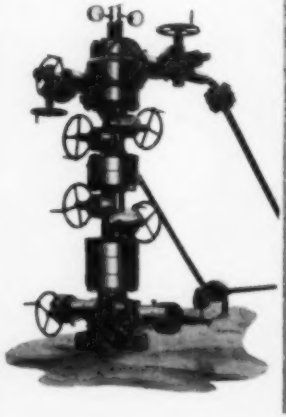
Balanced Stem Valves
Sizes: 2", 2½", 3" and 3½"
10,000 lbs. Working Pressure
Sizes: 1⅜", 1⅝", 2⅛" and 2⅜"
15,000 lbs. Working Pressure

Cross Type Valve (4" cross)
Sizes: 6" x 6" and 6" x 7"
2000 lbs. thru 5000 lbs. Working Pressure



Unequal Flange Cross Type Valves (2" cross)
Sizes: 2", 2½", 3", and 4"
2000 lbs. thru 5000 lbs. Working Pressure

Recessed Body Valves
Sizes: 1½", 1¾", 2", 2½" and 3"
2000 lbs. thru 5000 lbs. Working Pressure



Drilling Valves
Sizes: 6" x 7" and 6"
2000 lbs. thru 5000 lbs. Working Pressure

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

CONDUIT GATE VALVES

FOR

EVERY PRODUCTION SERVICE

A wide range of sizes . . . working pressures from 500 to 15,000 pounds . . . flange, unequal flange, screw or screw by flange end connections . . . multiple zone completion valves and cross type valves give you the *right* choice in a W-K-M Valve for every well completion job. Easy operation, DOUBLE-TIGHT SEAL, long life and positive CONTROLLED FORCE SEATING make W-K-M Valves the safest and most economical to use in the oil field.

You receive two special benefits from the parallel expanding gate feature of W-K-M Valves. When the valve is being opened or closed, the gate and segment are contracted together by a powerful spring to allow a slight clearance between them and the body seats for easy operation. After the gates have reached the opened or closed position, the gate and segment expand with CONTROLLED FORCE SEATING against both the upstream and the downstream seats.

Acid and alkali resistant Teflon† inserts in the seat rings give DOUBLE-TIGHT SEALING to control the lightest of gases or the heaviest of crudes.

All standard W-K-M Valves have full-bore through conduits without crevices or other flow obstructions to cause turbulence and pressure loss. Special reduced port valves are available which provide all the advantages of standard valves, except that the conduit is of venturi design to permit a smooth flow transition with a minimum of pressure drop.

SUPERIOR FEATURES—STANDARD ON W-K-M

• *Through-Conduit* • *Parallel Expanding Gates give CONTROLLED FORCE SEATING* • *Teflon seat inserts for DOUBLE-TIGHT SEAL** • *Two Thrust Roller Bearings* • *Pressure Seal Bonnet* • *Enclosed Packing Gland* • *Superfinished Stems* • *Fully Repairable while Installed*

Design and operating advantages, as well as sizes and dimensions of all valves are contained in W-K-M Catalog 200. Address Dept. F-11 for your copy.

W-K-M

DIVISION OF acf INDUSTRIES INCORPORATED

PLANT: MISSOURI CITY, TEXAS
MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

W-K-M IS A REGISTERED TRADEMARK OF ACF INDUSTRIES, INCORPORATED
† DUPONT'S TETRAFLUOROETHYLENE RESIN. * PAT. PENDING
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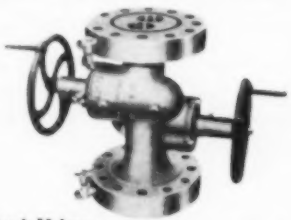
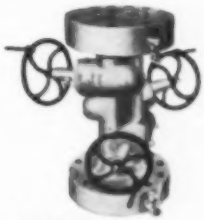
5721

MANUFACTURERS OF W-K-M GATE VALVES · ACF LUBRICATED PLUG VALVES · KEY-KAST ALLOY STEEL PIPING FITTINGS · KEY RETURN BENDS AND FITTINGS

Reduced Port Valves
Size: 2" x 1⅝"
5000 lbs. Working Pressure



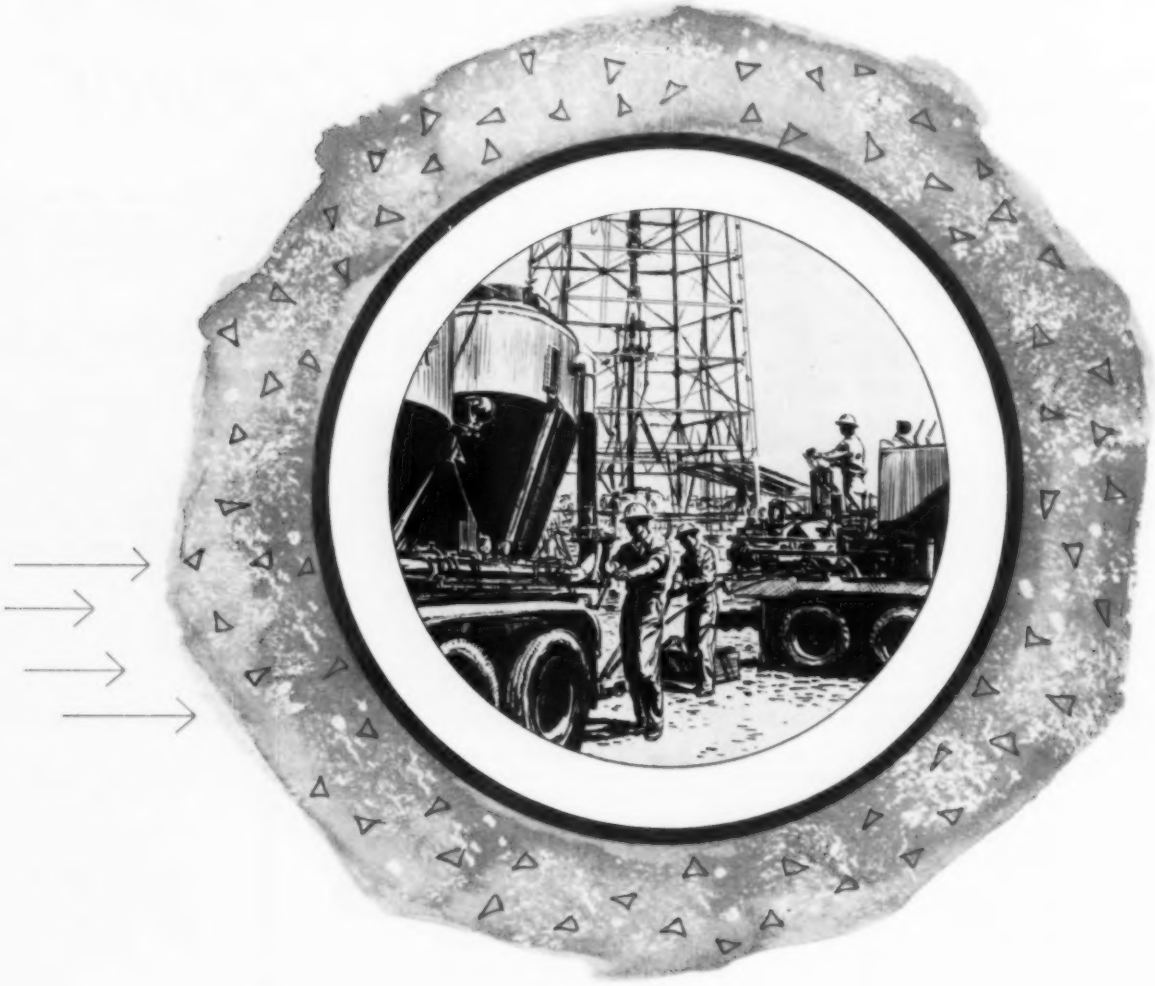
Dual Valves
Sizes: 1½" x 1½" and 1¾" x 1¾", 2" x 2", 2" x 2½", 2½" x 2½", 2½" x 3", 3" x 3"
2000 lbs. thru 5000 lbs. Working Pressure



Triple Valves
Size: 2" x 2" x 2"
2000 lbs. thru 5000 lbs. Working Pressure

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

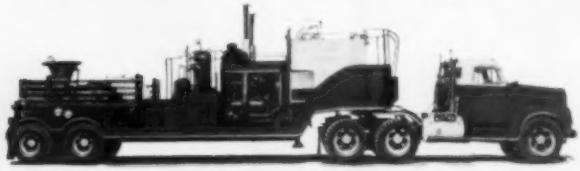
GIVE YOUR WELL
THE PROTECTION IT DESERVES



Every well operator knows that it doesn't pay to take unnecessary chances. That's why special care is essential in specifying the best oil well cementing to help protect the time and money already invested.

Halliburton cementing techniques and materials, in combination with specially designed tools and equipment, do just that. By giving added protection to possible producing zones behind the casing and by helping to safeguard against blowout, contamination and other hazards, a Halliburton cementing job can assist substantially in prolonging profitable well life and increasing your settled production rate.

To help extend the producing life of your well... to help increase its net BOPD... give your well the protection it deserves. Specify cementing by Halliburton.



HALLIBURTON

OIL WELL CEMENTING COMPANY, DUNCAN, OKLAHOMA

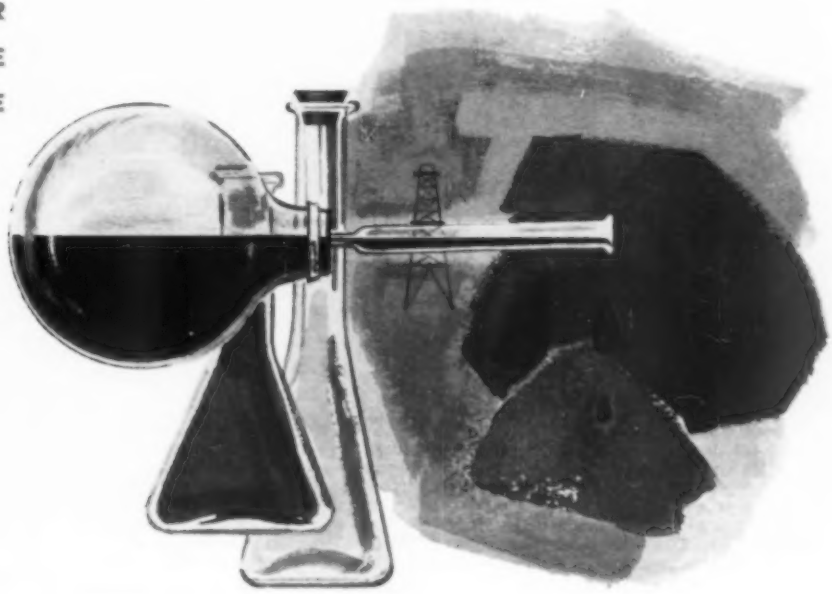
HR-4 CEMENT RETARDER . . . used in portland or Pozmix Cement to retard the set, allowing placement at high temperatures. A small amount added to dry cement or in the mixing water provides a tailored composition for cementing in the deepest of wells.

HR-7 CEMENT DISPERSANT AND RETARDER . . . effective in obtaining smoother and more fluid cement slurries . . . For use with high gel cement compositions . . . Most applicable in wells of moderate temperatures.

MUD-KIL . . . effectively neutralizes the cement-retarding properties of quebracho and other tannins, starch, sodium carboxymethyl cellulose and lignite . . . Pumping time and compressive strengths of cement are unaffected . . . A dry, granular material that may be mixed in the dry cement or dispersed in the mixing water.

THESE HALLIBURTON CEMENTING ADDITIVES MEAN BETTER PROTECTION, LONGER PRODUCTIVE LIFE

HI-DENSE . . . designed to increase the density of cement slurry for controlling high pressure gas and oil zones . . . Ground to a fineness that requires a minimum amount of mixing water . . . Because of the high specific gravity of Hi-Dense, it is possible to weight cement slurries to 20 lbs./gal., yet still maintain adequate pumpability and strength stability at high temperatures.



CALCIUM CHLORIDE . . . an accelerator for portland or Pozmix Cement to increase the early strength and reduce the waiting on cement time . . . Most effective at low temperatures (40°-100°F.) for surface pipe or shallow wells.

PERLITE . . . lowers the weight of the slurry column and increases the slurry volume per sack . . . The addition of Perlite and from 2%-6% bentonite to cement increases the amount of water required to mix a slurry of the proper viscosity for oil well cementing.

CEMENTING SERVICES

"A WELL WORTH CEMENTING IS WORTH CEMENTING WELL"

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Phases of Water Well Systems, Pumps and Other Equipment. Bulletin 100 very briefly describes the equipment and services available through Layne Associate Companies. Layne specializes in the development of ground water . . . in the manufacture of vertical turbine pumps and other allied equipment . . . and in special drilling and service work. *Layne & Bowler, Inc.*

Circle number (20) on reply card.

Portable Aluminum Utility Buildings. M & P, Inc.'s new folder on portable aluminum utility buildings gives the advantages, specifications and a partial list of present users of these economical and versatile units. Their adaptability to any use where additional or portable space is required has made these aluminum structures a practical purchase for the buyer interested in obtaining sound, lasting value at low cost. *M & P, Inc.*

Circle number (21) on reply card.

Rapid Operation of Offshore Platforms. A colorful 6-page folder, with 20 illustrations, has been prepared by R. G. LeTourneau, Inc., to describe its line of self-contained heavy-duty offshore platforms.

To illustrate outstanding features of the line, the brochure discusses in detail the size, capacities, and operational versatility of one specific unit, "The Vinegarroon." This particular platform, it is explained, was delivered some months ago and already has achieved an outstanding record for versatility and efficiency. *R. G. LeTourneau, Inc.*

Circle number (22) on reply card.

Mud Pump V-Belts. A bulletin on stock slush pump sheaves and V-belts has been designed specifically for oilfield drilling applications. The 12-page bulletin contains charts and tables which enumerate horsepower ratings and standardized dimensions of slush pump QD sheaves and V-belts. It also contains information about special features of the Worthington QD sheaves for slush pump service and pictorially illustrates actual applications of the Worthington QD slush pump sheaves in oilfield drilling processes. *Worthington Corporation.*

Circle number (23) on reply card.

Offshore Crane. New Sea-Crane catalog is being offered to offshore oil drillers and personnel responsible for supply of offshore rigs. It covers a line of 5 pedestal-mounted lifting cranes that have been specially designed for mounting on tenders, lighters and other offshore supply craft. These recently introduced machines are rated at from 12½ to 35-ton lifting capacities. *Link-Belt Speeder Corporation.*

Circle number (24) on reply card.

Wire Line Valve Brochure. A new 4-page brochure describes and illustrates the light, safe OMSCO wire line valve. It features a pressure seal needing no adjustment or lubrication and affords pressure control during wire line operation emergencies without having to cut the wire line. *Bowen Itco, Inc.*

Circle number (25) on reply card.

Technical Talk. Schlumberger Well Surveying Corporation announces the publication of the first issue of "Tech-Talk," a new technical newsletter.

The first issue of "Tech-Talk" deals with a tool for moisture analysis, the Schlumberger Nuclear Magnetic Resonance Analyzer, Model 104. The Model 104 NMR Analyzer is an analytical instrument used for the quantitative measurement of hydroenous liquids (water and oils) in solid materials. It is particularly suitable for rapid, non-destructive measurement of moisture in granular or fibrous solids, with very high accuracy and reproducibility. This illustrated, 6-page "Tech-Talk" explains nuclear magnetic resonance and describes in detail how the NMR Analyzer operates. *Schlumberger Well Surveying Corp.*

Circle number (26) on reply card.

Cleaning and Maintenance Handbook. "How to Use Measured Work Techniques to Reduce Cleaning and Maintenance Costs" is the title of a 28-page, illustrated handbook telling how to reduce labor costs in building cleaning and maintenance operations through the use of measured work studies. It explains (1) how to accurately determine your cleaning costs; (2) how to establish job

time requirements; (3) how to conduct a basic time study; (4) the importance of determining proper work loads; (5) how to establish quality and frequency standards; (6) how to simplify future maintenance problems when planning new construction; (7) how to establish and maintain daily work schedules, and (8) how to select proper equipment. *Advance Floor Machine Company.*

Circle number (27) on reply card.

Batteries—from Theory to Maintenance. The complete scope of motive-power battery maintenance and repair is described in a revised edition of the "Battery Users Manual," just issued by the industrial division of Gould-National Batteries, Inc. Encompassing every phase of battery maintenance, repair and selection this manual includes over 60 photographs, diagrams and tables to review battery theory and construction, demonstrate proper battery selection, illustrate charging method and equipment, demonstrate battery testing and techniques, and to present correct battery room layout. *Gould-National Batteries, Inc.*

Circle number (28) on reply card.

Liquid Cyclones Brochure. Equipment Engineers, Inc., announces a new Bulletin No. 830. The 16-page brochure features installation photos and performance data on many widely diversified applications of the Krebs Cyclones. *Equipment Engineers, Inc.*

Circle number (29) on reply card.

Rig Engines. Caterpillar diesel engines for all types of drill rigs is the topic of a new 8-page, 2-color booklet. Titled "Universal Rig Power," it outlines the manner in which Caterpillar engines supply well-drilling power for both diesel-electric or mechanical rigs, on both land and offshore. *Caterpillar Tractor Co.*

Circle number (30) on reply card.

Two-Way Radio. Bulletin ECR-490A on new transistorized power supply for 2-way radio units, provides advantages of transistor power without obsoleting the user's existing radio equipment. The cost of installing the device is written off in savings from lowered maintenance expenses resulting from fewer vibrator replacements and service calls. *General Electric Communication Products Department.*

Circle number (31) on reply card.

Packaged Electric Power. How 2 hp can do the job of 160 hp, for keeping truck radio batteries charged, is described and illustrated in Onan's new "Mobile Installations" folder, Form F-111. The well-illustrated, 8-page folder describes 3 packaged power systems, each specifically engineered to provide dependable, low-cost electric power for all users of mobile communications equipment. The brochure points up the heavy drain on vehicle batteries when mobile radios are used and the truck engine is not running and tells in detail how Onan's little 2-hp engine-driven electric plants do the job of the 160-hp truck engine, with the resultant savings in gasoline and truck engine maintenance. *D. W. Onan & Sons, Inc.*

Circle number (32) on reply card.

Diesel Power Unit Line. International Harvester has announced a new 12-page catalog covering its line of 6 diesel power units. The booklet provides "the inside story" on the 3 4-cylinder units, the UD-281, UD-350, and UD-14A, which range in horsepower from 60 to 76, and on the more-powerful 6-cylinder jobs, the UD-525, UD-18A, and the UD-1091, which embrace a wider range of power, from 115 to 200 hp. *Construction Equipment Division, International Harvester Co.*

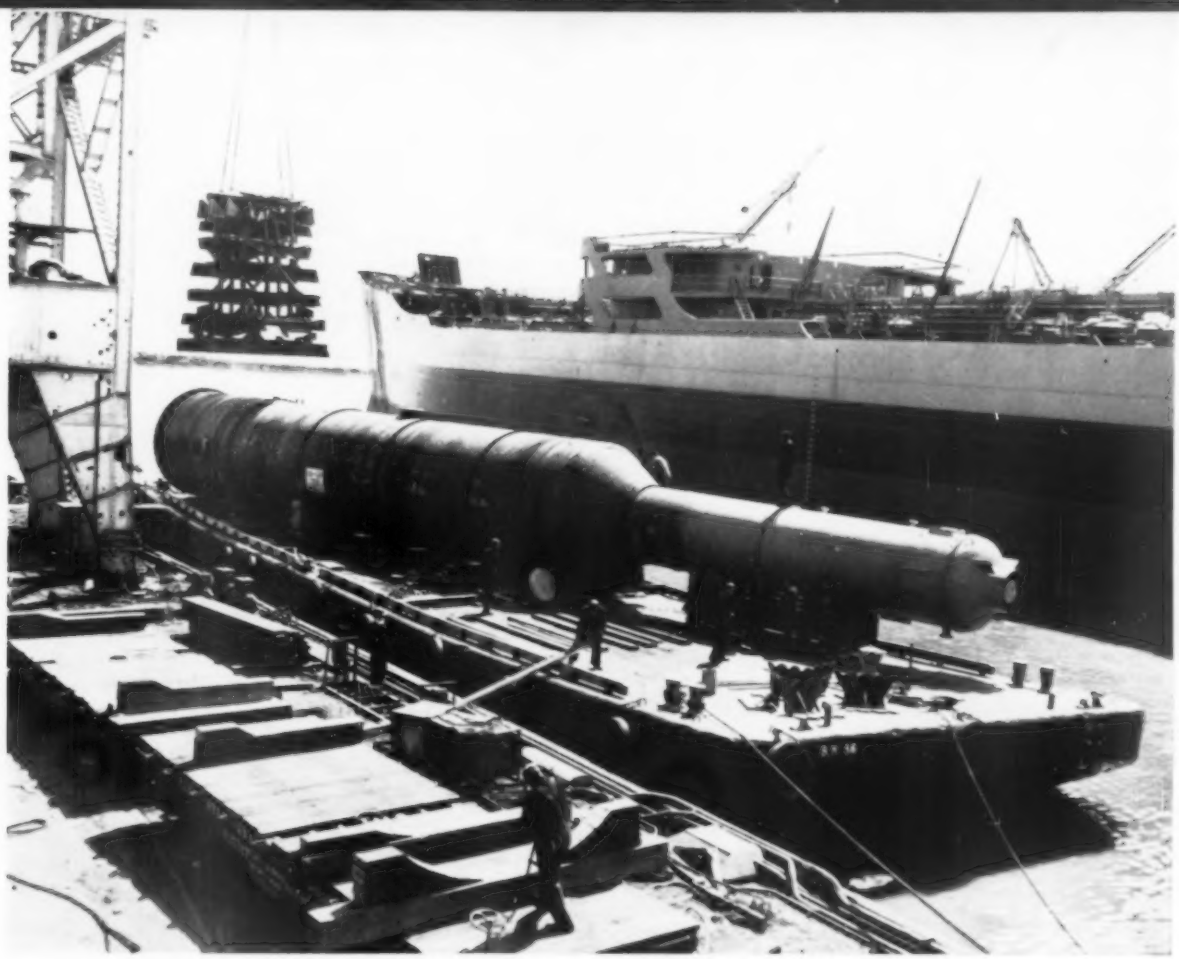
Circle number (33) on reply card.

Thoro-Link V-Belting. A new link type V-belting is being distributed by Dayton Rubber Company to further expand its complete industrial line of V-belts for all types of power transmission drives. Known as Thoro-Link V-Belting, it is described in a folder by the same name. Thoro-Link V-Belting comes in all sizes in both regular and oil-proof construction to cover every type of application. *The Dayton Rubber Company.*

Circle number (34) on reply card.

Electric Brakes and Clutches. Warner Electric Brake & Clutch Company announces new 8-page Catalog Digest WEB 6292 giving easy to read facts about electric brakes, clutches and controls for miniature mechanisms or high torque machine drives. *Warner Electric Brake & Clutch Company.*

Circle number (35) on reply card.



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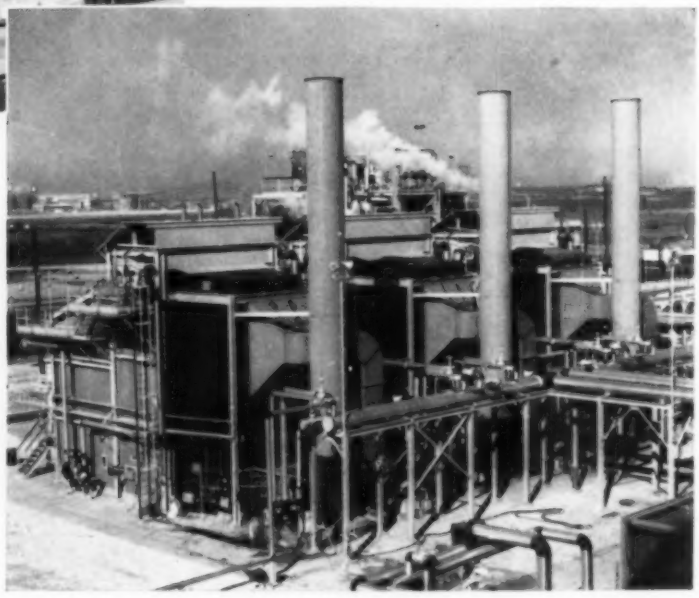

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New Projects in refining gas processing petrochemicals

Kerr-McGee Oil Industries has purchased an entire crude unit from the shut-down Tidewater Oil Company refinery at Drumright, Oklahoma. To be enlarged and modernized prior to installation, the unit will have a daily capacity of 23,000 bbl. Shell stills at Kermac's Cushing refinery will be retired, with a 7000 BPD modern unit to remain in use, thus boosting total capacity from 22,000 to 30,000 BPD. Engineering work is being done by Litwin Engineering Company. Kermac is also planning to install a cat reformer at Cushing.

Sinclair Oil & Gas Company plans a 10 MMcf/D gas processing plant in Lea County, New Mexico. To handle gas from three local pools — Gladiola, North Gladiola, and Bronco — compressor capacity will be 185 percent of present gas production. Dry, desulfurized gas will be returned for lease use, also sold to a gas pipeline. Liquids recovery will total 36,000 gal/day upon completion in the fall of 1958.

National Petro-Chemicals Corporation will build a 75-million lb/yr polyethylene plant on a 200-acre site adjacent to the Houston Ship Channel. Ethylene will be purchased from Phillips Chemical Company's Adams terminal purification facilities, which receives crude ethylene from Phillips' Sweeny, Texas, refinery via a 70-mile pipeline. To be built by M. W. Kellogg Company, plant will be completed by late 1958. National Petro-Chem now has a polyethylene plant at Tuscola, Illinois.

Hess Trading and Transport Company is planning a New York-area refinery, to be built on a 100-acre site at Port Reading, New Jersey. Projected cost is $8-million.

Standard Oil Company (Indiana) is raising the steelwork for a third Ultraformer, similar to its 21,000 BPD No. 2 Ultraformer that recently went onstream at Whiting refinery.

Phillips Petroleum Company is building a unit at Borger, Texas, to separate 13,500 BPD of isopentane from pentane fractions processed in a Penex isomerization unit. The Penex unit is designed by UOP, being built by Phillips, and will be completed by the first quarter of 1958. Phillips is also building facilities at its Sweeny, Texas, refinery for additional isopentane separation.

ANCAP, Administration Nacional de Combustibles Alcohol y Portland, is expanding its La Teja refinery at Montevideo, Uruguay. New equipment will include a 28,000 BPD crude unit, a 10,000 BPD vacuum unit, a 5000 BPD Orthoflow cat cracker, a 3000 BPD S-B-K cat reformer, a 4500 BPD gasoline treating unit, and the usual light ends processing equipment.

Standard Oil Company (Ohio) is relegating its Latonia, Kentucky, refinery to asphalt manufacture only. The 16,000 BPD refinery had been making motor, jet, and fuel oils along with 3000 BPD of asphalt. Rise in asphalt demand is the reason, according to manufacturing Vice President E. B. McConnell.

Foster Grant Company is now completing a $2.5-million expansion program for its styrene, nylon, and other facilities at Leominster, Massachusetts, and Manchester, New Hampshire; is now going directly into a $5.4-million additional expansion at those locations.

Standard Oil Company of California is building a $250,000 deisobutanizer at its El Segundo refinery. The unit should be onstream by mid-December 1957, and will increase isobutane recovery by some 300 BPD.

An affiliate of Standard Oil Company (N. J.) will build a 31.5-million bbl/yr (about 86,500 BPD) refinery near Rotterdam, Netherlands, at a cost of $46.5-million. The plant will be 150 percent larger than the one originally planned, is scheduled for startup by early 1960. Process design is to be done by Esso Research and Engineering Company, construction by Badger-Comprino N.V.

Standard Oil Company of California's Western Operations, Inc., has concluded a "conditional agreement" with the James Campbell estate at Oahu Island, Hawaii, for a 300-acre site for its long-proposed refinery there.

The Texas Company's natural gasoline plant to be built in the Four Corners area and announced in last month's RE, will be a "multi-million dollar" project for the recovery of natural gasoline, propane, and butane. Stripped gas will be returned to the Aneth field for repressuring. Ownership is shared with Gulf, Phillips, Superior, Pan American, Shell, and Humble.

A 3750 BPD sulfuric acid alkylation unit is being built at Standard Oil Company of Ohio's Cleveland No. 1 refinery under license from Esso Research and Engineering Company. Arthur G. McKee is building the $3.8-million unit, with initial operations scheduled for May 1958.

Firestone Tire & Rubber Company is planning expansion of its Orange, Texas, butadiene plant, onstream just five months ago. The plant now supplies 40,000 tons annually of butadiene, mostly for Firestone's 190,000 ton/yr synthetic rubber plant at Lake Charles, Louisiana.

Commerce Oil Refining Company has let contract for more than $50-million for design, engineering, and construction of a 43,000 BPD refinery at Jamestown, Rhode Island. Sixty percent of the plant's production will be 100-plus octane number motor fuel.

Lion Oil Company Division of Monsanto Chemical Company will build a 5000 BPD cat reformer, a hydrodesulfurization unit, and a 100,000 lb/hr steam boiler at its El Dorado, Arkansas, refinery. Bids were invited in late September, with construction to start in early 1958, completion late in 1958.

Standard Oil Company of California, Western Operations, Inc., has announced plans for a 60,000 BPD refinery at Mulkiteo, Washington, on the Puget Sound about 20 miles north of Seattle. The $75-million refinery will occupy a 2000-acre site and will process both California and Canadian crudes.

Switzerland will have an oil refinery, according to plans for financing one of undisclosed capacity. Proposed location is in Ticino Canton, near the Italian border. Financiere Italo-Suisse will underwrite the project, which is sparked by the increase of Swiss oil imports from 20,000 to 60,000 BPD during the past six years.

Canadian Oil Companies, Ltd. will again expand its Sarnia, Ontario, refinery. Expanded four years ago from 20,000 BPD to the current 30,000 BPD capacity, an additional 20,000 BPD increase is now planned. A 20,000 BPD crude unit, costing $4-million, will be completed in early 1959, with the remainder of the program to be finished in 1961.

Clark Oil and Refining Corporation is planning a $7.2-million program at its Blue Island, Illinois, refinery for expansion of capacity from 21,000 BPD to 30,000 BPD, will also boost gasoline production per barrel of crude by about 30 percent via addition of a catalytic cracking unit.

Ethyl Research Performance of Today's

by T. W. Warren

Director, Refinery Technology, Ethyl Corporation Research Laboratories

A premium fuel being road tested in one of Ethyl's controlled-weather rooms that duplicates road conditions exactly.

Reports on Premium Fuels

NINETY-ONE premium gasolines and 12 third-grade super-premium fuels have been tested on the road and in the laboratory in a research program recently completed by Ethyl's Detroit Research Laboratories.

The results of this investigation have been published in a 140-page report entitled "Antiknock Behavior of Premium Motor Fuels, 1957", now available to all companies in the Oil and Automotive Industries.

The fuels tested were submitted by 83 refineries of 48 American companies. These refineries produce 75 per cent of the motor fuel in the United States. Seven Canadian companies, producing an appreciable percentage of Canada's gasoline needs, also submitted fuel samples for testing.

Each Gasoline Tested 32 Times

Five 1957 cars normally requiring premium fuels, and three cars equipped with experimental 11 to 1 compression-ratio engines were used in the tests. A minimum of two Modified Uniontown and two Modified Borderline ratings were obtained for each gasoline in each car, a total of at least 32 road ratings for each fuel sample.

Extensive laboratory data, including determinations of tetraethyllead susceptibility, hydrocarbon type, and bromine number, were also obtained and are included in the report.

Test Results Point to Future Gasoline Developments

The broad sampling of premium fuels tested gave an accurate picture of today's premium gasolines and how they perform in the cars of today and in the higher compression engines of tomorrow. A complete analysis of all the test data led to the following conclusions affecting refining economics:

1. Sensitivity (the difference between Research and Motor octane number) often is an unreliable measure of road performance through the normal speed range.

2. Research and Motor octane numbers can be used to predict road performance at low speeds but are less reliable at intermediate and high speeds.

3. At higher speeds, road performance increases when the aromatic content of the gasoline is increased.

The 103 premium and super-premium gasolines in these drums were tested for Ethyl Corporation's 1957 premium fuel survey. This is the fifth premium survey conducted by Ethyl since 1946.

An important by-product of this program was the development of a system for calculating the road octane number of a gasoline. This development will permit individual refiners to determine the "road octane number" of their gasoline blends using the results of simple laboratory tests.

How Ethyl Research is helping you

Since World War II, Ethyl Corporation has investigated the laboratory and road performance of premium-grade gasolines in 1946, 1949, 1951 and 1954. During this period, the number of fuels analyzed has increased from 12 gasolines in 1946, to 63 in 1954 and 103 in 1957.

"Antiknock Behavior of Premium Motor Fue's, 1957" is one more example of Ethyl's continuing service to the Oil Industry. Copies can be obtained from your Ethyl Representative or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

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NEW GRAPHICAL METHOD SPEEDS

Design of multicomponent distillation towers

R. J. Hengstebeck
Research Department
Standard Oil Company (Indiana)
Whiting, Indiana

Reduction of the multicomponent system to a binary system of key components or "effective keys" is used to determine tray and reflux requirements. The method can be used for single and dual-feed towers, with or without a sidestream

RIGOROUS solutions of multicomponent distillation problems require numerous assumptions that must be checked subsequently by heat and material balances and equilibrium relationships. If rigorous solutions are to be obtained with minimum effort, the assumptions must be made and checked in the optimum sequence. Use of a poor sequence will often increase the time and energy required several-fold. Although many methods of calculation have been advanced, optimum procedures have seldom been discussed. In the following paragraphs a procedure is recommended for a graphical calculation method that was recently published.[4] The procedure consists of preparatory calculations, determination of reflux and tray requirements, and determination of how non-key materials split between the product streams. Tray and reflux requirements are established by reducing the multicomponent system to a binary system of the key components or, sometimes, of "effective keys," each of which consists of a group of close-boiling components. The procedure is outlined for a tower with a single feed and no sidestream, and modifications are described for towers with two feeds or with sidestreams.

Preparatory Calculations

Preparatory to solving a distillation problem, the basic information must be assembled. For a simple tower with a single feed and no sidestream:

1. Determine the composition of the feed. Doing so may require "stepping off" components on a true-boiling-point curve, as illustrated in Fig. 1. For the individual components, it is usually convenient to assume plateaus at the boiling points of the n-paraffins, because equilibrium (K) ratios for n-paraffins are readily available. True-boiling-point curves can be estimated from ASTM distillation curves.[1]

2. Define the separation by setting the splits of two key components between the overhead and bottoms streams. To determine whether "effective keys" should be used, locate the points for the keys on a log plot of $\frac{d}{b}$* against relative volatility, draw a straight line through them, and read off $\frac{d}{b}$ ratios for the other components[2, 4] as shown

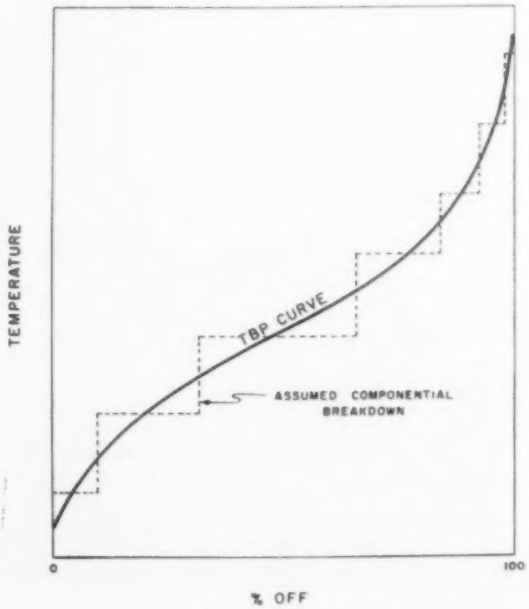

FIG. 1. Estimation of feed components from a true-boiling-point curve.

*All terms are defined at the end of the article.

in Fig. 2. Include in the "effective light key" the components with ratios less than $10\left(\frac{d}{b}\right)_{lk}$ and include in the "effective heavy key" the components with ratios greater than $0.1\left(\frac{d}{b}\right)_{hk}$. If any component is intermediate between the keys, include it in the effective light key if its $\frac{d}{b}$ is greater than 1, in the effective heavy key if its $\frac{d}{b}$ is less than 1. Determine the $\frac{d}{b}$ ratio for an effective key by summing it's d's and dividing by the sum of its b's; read its relative volatility from the plot of log $\frac{d}{b}$ vs log α. The value obtained applies at the temperature and pressure for which the plot was drawn. If relative volatilities vary through the tower, variations in the relative volatility of an effective key** are determined, in subsequent calculations, from the variations in the relative volatility of a representative component.

3. Set the operating pressure for the column. The pressure must be such that the bottoms can be reboiled and the reflux can be condensed by exchange with the available heating and cooling media. The tower-bottom temperature is the bubble point of the bottoms. The reflux-drum temperature is the bubble point of the net overhead if it is withdrawn from the reflux drum as a liquid, the dew point of the net overhead if it is withdrawn as a vapor. Because of pressure drops in the tower and in the overhead system, the reflux-drum pressure will be lower than the tower-bottom pressure. Except for vacuum towers, the pressure drop between the tower bottom and the reflux drum is usually assumed to be 5 to 10 psi.

4. Approximate the temperature of the top tray from the dew point of the net overhead product (this procedure is exact if a total condenser is used), and determine the relative volatilities of the keys at the top and bottom of the tower.

5. Determine the physical state of the feed. If it is mixed liquid and vapor, make an equilibrium-flash-distillation calculation to obtain F_l and F_v.

For a two-feed tower, the preliminary steps are the same except that, for determining the effective keys in Step 2, the feeds are combined, and the physical state of each feed is established in Step 5.

For a tower with a sidestream, the preparatory steps are also the same as for a simple tower, except that three products must be specified, instead of two. A tower with a sidestream has two pair of keys, and two splits must be set. Setting the splits is straightforward when the sidestream is stripped. To set the complete split when there is no stripper, however, the components lighter than the lightest key must be apportioned between the distillate and the sidestream. For purposes of the preparatory calculations, these components are assumed to be taken overhead completely. How they actually split between the distillate and sidestream is determined in conjunction with the subsequent calculations of reflux and tray requirements.

**To simplify the remaining discussion, the terms "light key" and "heavy key" will refer to the effective keys whenever effective keys are used.

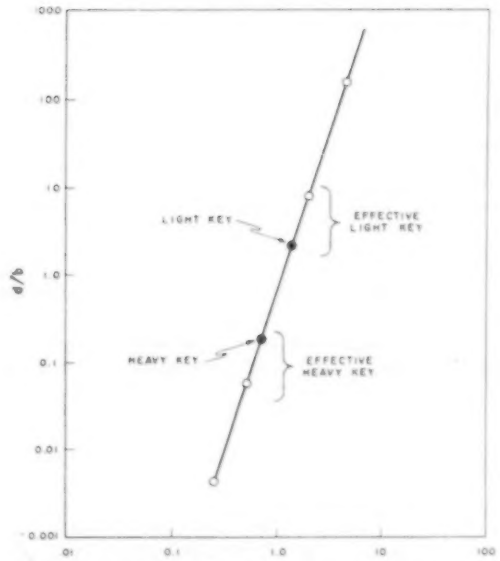

FIG. 2. Estimation of splits between overhead and bottoms.

TABLE 1. Sample Calculations at Feed Inlet.[4]

Basic Information From Previous Calculations

Component		α	f	d	b	l	v	l'	v'
A		4.0	59	59.0	—	19.7	78.7	—	—
B	keys	2.0	10	9.5	0.5	—	—	—	—
C	keys	1.0	5	0.3	4.7	—	—	—	—
D		0.5	26	—	26.0	—	—	34.7	8.7

$L = 35.2$, $V = 104.0$; $L' = 135.2$, $V' = 104.0$.

Intersection of limiting lines is at $x_e = 0.86$; α of combined keys $= 1.86$ l_{f-1} for component D $= 4.7$; v_f for component A $= 18.7$.

Calculations Up From Feed Inlet

Component	d	α	f+1	al_{f-1}	v_{f-1}	l_{f-2}	al_{f-2}	v_{f-2}	l_{f-3}
A	—	—	19.7	—	78.7	19.7	—	78.7	19.7
B+C	9.8	1.86	10.8	20.0	22.6	12.8	23.8	23.9	14.1
D	0.0	0.50	4.7	2.4	2.7	2.7	1.4	1.4	1.4
			35.2	22.4	104.0	35.2		104.0	35.2
$\frac{v}{l}$ (for B+C)			0.53			0.57			0.59

Calculations Down From Feed Inlet

Component	b	α	v'_f	v'_{f-a}	l'_f	v'_{f-1}	v'_{f-1-a}	l'_{f-1}	v'_{f-2}
A	0.0	4.00	26.6	19.2	66.0	66.0	16.5	51.7	51.7
B+C	5.2	1.86	18.7	10.0	34.5	29.3	15.8	18.8	43.6
D	—	—	8.7	—	34.7	8.7	—	34.7	8.7
			104.0		135.2	104.0		135.2	104.0
$\frac{l'}{v'}$ (for B+C)					1.18			1.12	

Reflux and Tray Requirements for Single Feed

Reflux and tray requirements are determined by a modified McCabe-Thiele procedure in which the multicomponent

system is reduced to an equivalent binary. For a tower with a single feed and with no sidestream:

1. Determine the limiting flow rates* for the non-key materials — for each light non-key in the rectifying section and for each heavy non-key in the stripping section:

	Rectifying Section	*Stripping Section*
Liquid	$l = \frac{\alpha_{hk}\, d}{\alpha - \alpha_{hk}}$	$l' = v' + b$
Vapor	$v = l + d$	$v' = \frac{\alpha b}{\alpha_{lk} - \alpha}$

Note that italicized type is used to express limiting flow rates.

If relative volatilities vary through the tower, use values at an intermediate temperature. Sum the limiting flow rates to obtain Σl, Σv, $\Sigma l'$, and $\Sigma v'$.

2. To facilitate the selection of a reflux rate, calculate the "q" value[8] for the feed on the assumption of equal molal heats of vaporization:

$$q = \frac{F_l + \Sigma l - \Sigma l'}{F}$$

If the feed is at a temperature below its bubble point, T_B,

$$F_l = 1 + \left(\frac{c\,(T_B - T)}{H_v}\right) F.$$

If the feed is at a temperature above its dew point, T_D,

$$F_l = -\left(\frac{c\,(T - T_D)}{H_v}\right) F.$$

3. Construct a binary McCabe-Thiele diagram[7] of the keys and plot the q-line, as shown in Fig. 3. Also plot the equilibrium line in the vicinity of the q-line, and arbitrarily select a limiting operating line that intersects the q-line below the equilibrium line. The flow rates in the rectifying section are determined by the slope, Z, of the line selected. Limiting rates of the combined keys are:

$$L_e = \frac{Z\, D_e}{1 - Z} \qquad V_e = L_e + D_e$$

Total flow rates are:

$$L = L_e + \Sigma l \qquad V = L + D$$

*Except near the feed tray, heavy non-keys are absent from the rectifying section and light non-keys are absent from the stripping section. In the rectifying section, light non-keys cannot fall below their limiting rates, as here defined, so long as heavy components are absent. In the stripping section, heavy non-keys cannot fall below their limiting rates so long as light components are absent.

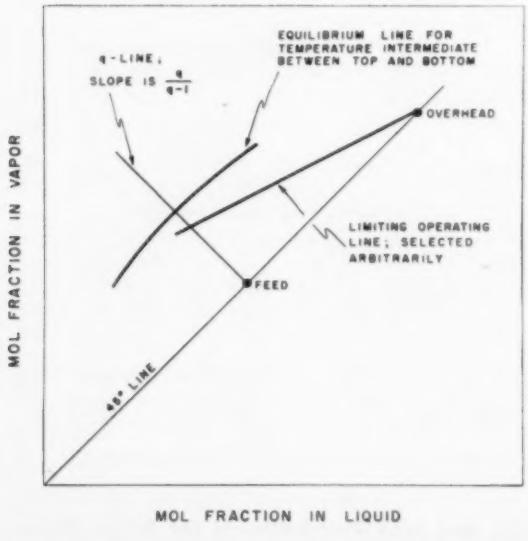

FIG. 3. How to select a reflux ratio from the q-line and the equilibrium line.

4. Determine the condenser duty when the L of Step 3 holds at an intermediate point in the rectifying section. Assume that the materials heavier than the keys are negligible and that the combined keys and the lighter materials are at their limiting flow rates. Set the keys at a proportion intermediate between that in the feed and in the overhead product. Determine the bubble point of the liquid and make a heat balance to obtain the condenser duty. Make a heat balance over the whole tower to obtain the reboiler duty. If the relative volatilities of the keys vary through the tower, obtain the value at the intermediate composition from these calculations.

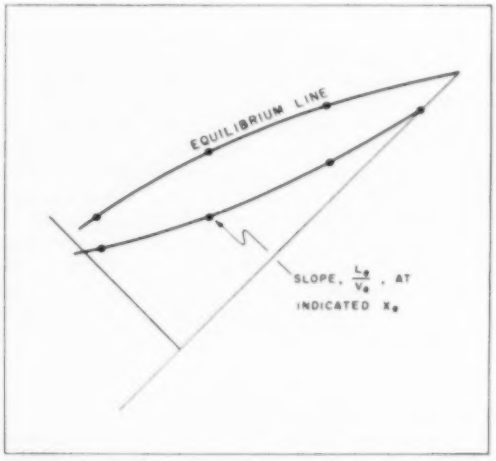

FIG. 4. Illustration of method for determining a curved limiting line.

In most cases little error results from assuming that limiting operation line is straight. If an exact solution is desired, however, determine the limiting vapor and liquid flow rates at three or four values of x_e in the rectifying section by assuming flow rates and checking them by heat balances. In each case, assume that the heavy non-keys are negligible and that the light non-keys are at their limiting values. If the limiting flow rates of the keys are not constant, draw a curved limiting line as illustrated in Fig. 4. If relative volatilities vary through the tower, obtain the value at each x_e from these calculations.

5. By trial and error, determine the liquid and vapor rates at an intermediate point in the stripping section. Assume that the light non-key materials are negligible and that each heavy non-key is at its limiting flow rate, l'. For the first trial, assume that heats of vaporization are constant; then the flow rate of the combined keys in the stripping liquid equals $L + F_l - \Sigma l'$. Set the proportions of the keys at a value intermediate between that in the feed and in the bottoms, determine the bubble point of the liquid, and calculate the reboiler duty. If the reboiler duty does not check, assume a new liquid flow rate for the combined keys and re-

peat the calculations. When a check is obtained, plot the limiting stripping line, with a slope of L'_e and V'_e.

The limiting stripping line so calculated can usually be assumed to hold for the whole stripping section, with little error. If an exact solution is desired, obtain the limiting flow rates at several values of x_e, and, if they vary, draw a curved limiting line, as illustrated for the rectifying section in Fig. 4.

6. If the relative volatilities of the keys vary through the tower and if the equilibrium line has not already been established, determine the relative volatility of the keys at several values of x_e in the rectifying and stripping sections, using compositions obtained as in Steps 4 and 5. Because compositions and temperatures may change rapidly near the feed tray, there may be a discontinuity in the equilibrium line at that point.[2] For a first approximation in such a case, draw the equilibrium line arbitrarily in the region of the feed inlet, as shown in Fig. 5. When there is such a discontinuity, the optimum feed-tray location will be below the intersection of the operating lines.[2]

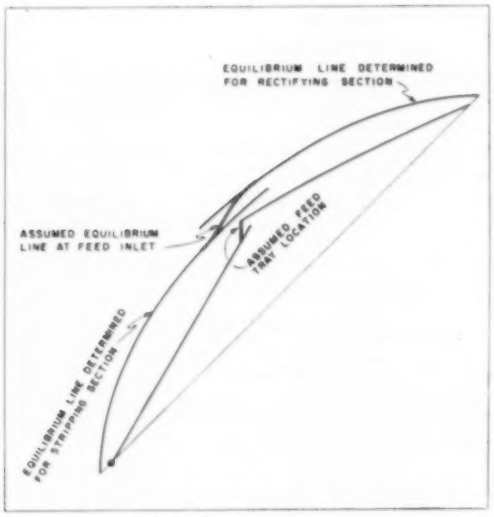
EQUILIBRIUM LINE DETERMINED FOR RECTIFYING SECTION
ASSUMED EQUILIBRIUM LINE AT FEED INLET
ASSUMED FEED TRAY LOCATION
EQUILIBRIUM LINE DETERMINED FOR STRIPPING SECTION

FIG. 5. Typical construction for relative volatilities in a multicomponent distillation tower.

7. Calculate tray-to-tray up from the bottom of the column and down from the top by the Lewis-Matheson method,[5] and plot the steps on the binary diagram. Carry the calculations forward in each case until the limiting operating line is approached as closely as desired. For an exact solution, make heat balances on each tray; however, in most cases little error will result from assuming that the flow rates calculated for the intermediate zones apply.

8. Determine the compositions at the feed tray and the tray above. They may be obtained straightforwardly from approximate relationships:

Components	v_f'	l_{f+1}
Light	$f_l + l$	l
Heavy	v'	$f_v + v'$
Combined keys	by difference	by difference

or by trial and error from exact relationships:

Components	v_f'	l_{f+1}
Light	$f_l + l_{f+1}$	$\dfrac{d}{KV/L - 1}$
Heavy	$\dfrac{b}{L'/KV' - 1}$	$f_v + v_f'$
Combined keys	by difference	by difference

Use of the approximate relationships will result in high tray requirements, but the errors will usually be negligible. The exact relationships are solved by assuming temperatures for the feed tray and tray above, determining the compositions, and checking the temperatures by a dew-point calculation on the feed-tray vapor and a bubble-point calculation on the liquid from the tray above.

9. Calculate up and down from the feed inlet to determine the slope of the binary operating line for each tray, and plot each operating line on the McCabe-Thiele diagram. Determine the slope of each operating line from the $\frac{l}{v}$ or $\frac{l'}{v'}$ ratio for the combined keys.* In calculating up from the feed inlet, hold the light non-keys at their limiting flow rates; in calculating down hold the heavy non-keys at their limiting rates. In both cases, treat the keys as a single component with a volatility estimated from the intersection of the limiting operating lines. Sample calculations are shown in Table 1. Continue the calculations in each case until an operating line approaches the limiting line as closely as desired. If the exact location of the equilibrium line near the feed inlet is important in a case where it was arbitrarily drawn, it should be checked and adjusted if necessary.

10. Starting at the intersection of the operating lines for the feed tray and the tray above, "step off" the tray requirements in both directions, using the appropriate operating line for each tray. Continue until the terminal compositions of Step 8 are reached. A typical final construction is shown in Fig. 6. When the operating lines for the feed tray and the tray above intersect on the equilibrium line, there are two theoretical trays at that point.[4]

*The l or l' is the liquid from the tray in question; the v or v' is the vapor to the tray.

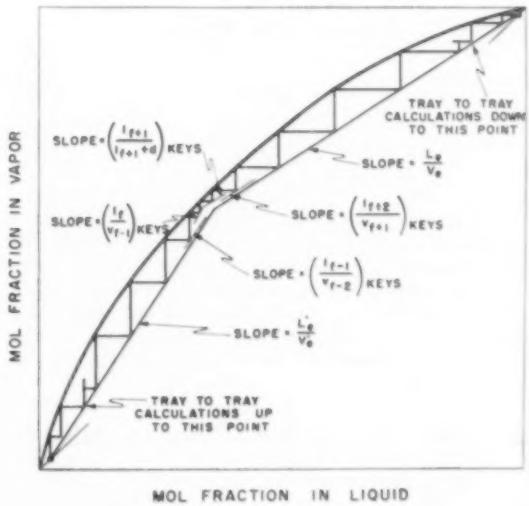
TRAY TO TRAY CALCULATIONS DOWN TO THIS POINT
SLOPE = $\left(\frac{l_{f+1}}{l_{f+1}+d}\right)$ KEYS
SLOPE = $\frac{L_e}{V_e}$
SLOPE = $\left(\frac{l_f}{v_{f-1}}\right)$ KEYS
SLOPE = $\left(\frac{l_{f+2}}{v_{f+1}}\right)$ KEYS
SLOPE = $\left(\frac{l_{f-1}}{v_{f-2}}\right)$ KEYS
SLOPE = $\frac{L'_e}{V'_e}$
TRAY TO TRAY CALCULATIONS UP TO THIS POINT
MOL FRACTION IN VAPOR
MOL FRACTION IN LIQUID

FIG. 6. Typical final construction for a multicomponent distillation problem.

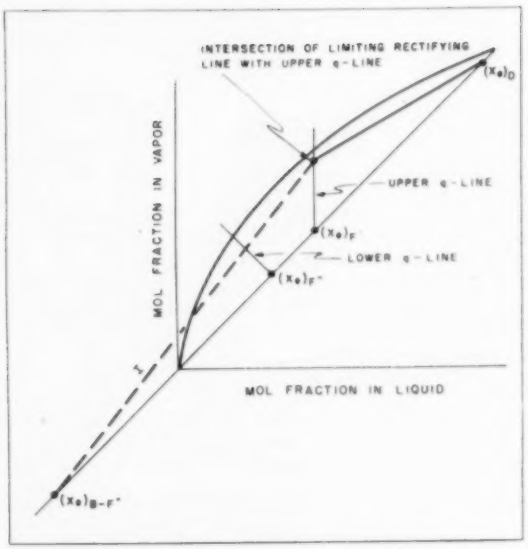

FIG. 7. Preliminary check of the assumed reflux ratio in a two-feed tower.

Reflux and Tray Requirements for Two Feed Streams

If a tower has two feed streams, the procedure is modified to take into account the section between the feeds:

1. In Step 1, the term "rectifying section" applies to the section above the upper feed, and "stripping section" applies to the section below the lower feed. In addition to determining the limiting flow rates for the non-keys in these sections, their limiting rates must also be determined in the intermediate section; these rates may either be approximated by a straightforward procedure:[3]

light components, $l_i = \dfrac{\alpha_{hk}(d - f')}{\alpha - \alpha_{hk}} \qquad v_i = l_i + (d - f')$

heavy components, $v_i' = \dfrac{\alpha(b - f'')}{\alpha_{lk} - \alpha} \qquad l_i' = v_i' + (b - f'')$

or calculated rigorously by trial and error:[3]

light components, $l_i = \dfrac{d - f'}{(KV/L)_i - 1} \qquad v_i = l_i + (d - f')$

heavy components, $v_i' = \dfrac{b - f''}{(L'/KV')_i - 1} \qquad l_i' = v_i' + (b - f'')$

Answers obtained from the approximate equations are slightly high, and tray requirements so calculated are also slightly high. Use of the rigorous equations involves assuming a temperature, calculating the vapor or liquid composition, and checking the temperature by a dew-point or bubble-point calculation. The equations are solved at the point defined by the binary composition of the keys that is midway between the compositions of the two feed streams.

2. In Step 2, the q value for each feed is calculated from:

for the upper feed, $q = \dfrac{F_i' + \Sigma l - \Sigma(l_i + l_i')}{F'}$

for the lower feed, $q = \dfrac{F_i'' + \Sigma(l_i + l_i') - \Sigma l'}{F''}$

3. In Step 3, two q-lines are plotted. Also, in selecting the limiting operating line in the rectifying section, the reflux rate is checked for adequacy in the stripping section. The point $(x_e)_{B-F''}$ is located on the 45° line, and a straight edge is laid through it and through the intersection of the limiting rectifying line with the upper q-line (see line I of Fig. 7). The straight line so determined should cross the lower q-line below the equilibrium line. If it does not, choose a new limiting line for the rectifying section and repeat the procedure. (Do not draw line I.)

4. In Step 5, the limiting operating line for the intermediate section is determined, as well as the limiting line for the stripping section. For the first trials, it is assumed that

$$(L_e)_i = L + F_i' - \Sigma(l_i + l_i')$$
$$L_e' = L + F_i' + F_i'' - \Sigma l'$$

When checks are obtained by heat balances, the limiting lines are drawn, with slopes of $(L_e/V_e)_i$ and L_e'/V_e'. A typical construction is shown in Fig. 8.

5. In Step 6, there may be two discontinuities in the equilibrium line, one at each feed tray. They are both treated in the manner outlined.

6. In Step 8, compositions must be established at two feed inlets. The approximate equations become:[3]

At the upper feed inlet:

Components	*Feed Tray*	*Tray Above Feed*
Light	$v_f' = l + f_l + v_l$	$l_{f+1} = l$
Heavy	$v_f' = v_l'$	$l_{f+1} = v_f' + f_v$
Combined keys	v_f', by difference	l_{f+1}, by difference

At the lower feed inlet:

Light	$v_f' = l_l + f_l$	$l_{f+1} = l_l$
Heavy	$v_f' = v'$	$l_{f+1} = v' + f_v + l_l'$
Combined keys	v_f' by difference	l_{f+1} by difference

The use of these equations may result in calculated tray re-

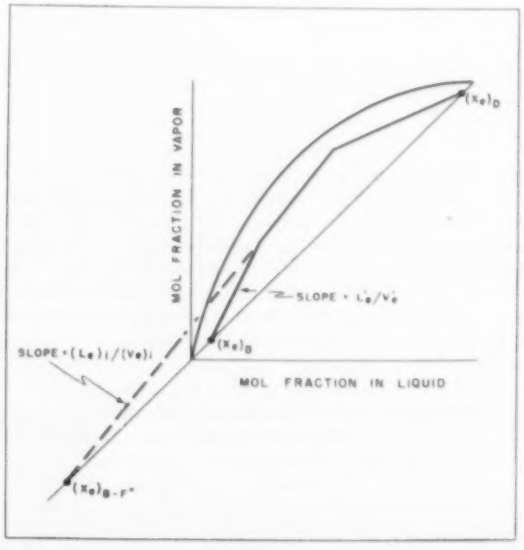

FIG. 8. Typical limiting diagram for a two-feed multicomponent tower.

quirements that are somewhat high, but the error is usually negligible. If an exact solution is to be obtained six substitutions are made:

At the upper feed inlet	*At the lower feed inlet*
$1 + \left(\frac{1}{\left(\frac{KV}{L}\right)_i - 1}\right)(d - f')$ for v_1	$\frac{b}{\frac{L'}{KV'} - 1}$ for v'
$\frac{b - f''}{\left(\frac{L}{KV'}\right)_i - 1}$ for v_1'	$\frac{d - f'}{\left(\frac{KV}{L}\right)_i - 1}$ for l_1'
$\frac{d}{\frac{KV}{L} - 1}$ for l	$\left(1 + \frac{1}{\left(\frac{L}{KV}\right)_i - 1}\right)(b - f'')$ for l_1'

The exact equations are applied at each inlet by assuming temperatures for the feed tray and the tray above, calculating the compositions, and checking the temperatures. In each case, the volatility of the combined keys is estimated from the intersection of the limiting operating lines.

7. In Step 9, calculations are made up and down from each feed inlet.

8. In Step 10, trays are stepped off in both directions from both inlets.

How to Include Sidestream Into Calculation

The section below the sidestream is taken as one tower; the section above it(together with the sidestream stripper if one is provided) is taken as the other.

It is usually convenient to solve the lower tower first. It is treated exactly as a simple tower except that:

a. The distillate and the sidestream combined constitute the net overhead,

b. The reflux to the top tray has the same composition as the sidestream drawoff. Hence, the tray-to-tray calculations down from the top are postponed until after the upper tower is solved.

If a sidestream stripper is provided, the upper tower is calculated as a simple tower with a feed consisting of the net overhead and sidestream combined.

If a sidestream stripper is not provided, the splits of the components lighter than the lightest key are first ascertained, and the split of the lightest key is checked for reasonableness. On the presumption that each component lighter than the lightest key approaches its limiting rate in the liquid,[6]

$$s = \frac{Sf}{(K-1)V + D + S}$$

In this equation, the temperature of the sidestream is first assumed, and its composition calculated. The temperature is then checked by a bubble-point determination.

The equation is also applied to the lightest key to determine its limiting flow rate. If the sidestream flow rate chosen for the lightest key is not higher than its limiting value, the assumed separation is not possible. Either the reflux must then be increased or a sidestream stripper must be employed. Alternatively, of course, more of the lightest key could be taken into the sidestream. With the complete split established, the trays above the sidestream drawoff are calculated by the procedure for a simple tower.

Splits of Non-Key Components

For a simple tower with a single feed and no sidestream, the splits of the non-key components can be approximated from the appropriate two of three equations,[4] in which subscript B refers to the light key, C to the heavy key, A to any component lighter than the keys, and D to any component heavier than the keys. For each component heavier than the keys, when the overhead product is taken off as liquid:

$$\left(\frac{l_{f+1}}{d}\right)_D = \alpha_{CD}^{n}\left[1 - \frac{\alpha_{CD} - 1}{\alpha_{CD}\left(\frac{l_1}{d} + 1\right)_C}\right]\left(\frac{l_{f+1}}{d}\right)_C \quad . \quad . \quad (1)$$

For each component heavier than the keys, when the overhead product is taken off as a vapor:

$$\left(\frac{l_{f+1}}{d}\right)_D = \alpha_{CD}^{n+1}\left[1 - \frac{\alpha_{CD} - 1}{\alpha_{CD}\left(\frac{l_o}{d} + 1\right)_C}\right]\left(\frac{l_{f+1}}{d}\right)_C \quad . \quad . \quad (2)$$

For each component lighter than the keys in either case:

$$\left(\frac{v_f'}{b}\right)_A = \alpha_{AB}^{n+1}\left[1 - \frac{\alpha_{AB} - 1}{\alpha_{AB}\left(\frac{v_r}{b} + 1\right)_B}\right]\left(\frac{v_f'}{b}\right)_B \quad . \quad . \quad (3)$$

In developing these equations, the following terms were assumed to be many times unity: $\left(\frac{l_2}{d}\right)_C$ in conjunction with Equation 1, $\left(\frac{l_1}{d}\right)_C$ in conjunction with Equation 2, and $\left(\frac{v_1}{b}\right)_B$ in conjunction with Equation 3. When the assumptions hold, the equations are almost exact.

If a tower has two feeds, Equation 1 or 2 is used for the heavy components at the upper feed inlet, and Equation 3 is used for the light components at the lower feed inlet.

If a tower has a sidestream drawoff, the equations are first applied to the "lower tower" to establish the complete feed to the "upper tower." The equations are then applied again to the "upper tower."

Discussion

The method here described permits a rigorous solution of any multicomponent distillation problem with little or no trial-and-error calculations. Unlike other rigorous methods, it automatically locates the optimum feed tray. Also it provides for the selection of a reasonable reflux rate without preliminary calculations to determine the minimum reflux rate. With relatively little experience, the designer can usually select a reflux rate near the optimum. If solutions at more than one reflux ratio are desired, the second and subsequent solutions are substantially faster than the first, because many of the flow quantities are independent of reflux rate. However, in such cases, it is usually preferable to determine the approximate relationship between reflux and trays graphically, using only the limiting operating lines.[2] The optimum case so determined is then checked by a rigorous calculation.

TABLE 2. Notation.

b = moles per hr of a component in the bottoms product.
B = moles per hr of bottoms product.
c = specific heat, btu per lb per F.
d = moles per hr of a component in the net overhead product.
D = moles per hr of net overhead product.
D_o = moles per hr of combined keys in net overhead product.
f = moles per hr of a component in the feed.
f' = moles per hr of a component in the upper feed to a two feed tower.
f'' = moles per hr of a component in the lower feed to a two-feed tower.
f_l = moles per hr of a component lighter than the keys in the feed as liquid.
f_v = moles per hr of a component heavier than the keys in the feed as vapor.
F = moles per hr of feed.
F' = moles per hr of upper feed to a two-feed tower.
F'' = moles per hr of lower feed to a two-feed tower.
F_l, F_l', F_l'' = moles per hr of liquid in a vapor-liquid feed.
F_v = moles per hr of vapor in a vapor-liquid feed.
H_v = heat of vaporization, Btu per lb.
K = vapor-liquid equilibrium ratio.
l = moles per hr of a component in the liquid from a rectifying tray.
l' = moles per hr of a component in the liquid from a stripping tray.
l = limiting moles per hr of a light component in the liquid from a rectifying tray.
l_1 = limiting moles per hr of a light component in the liquid from a tray between the feeds of a two-feed tower.
l' = limiting moles per hr of a heavy component in the liquid from a stripping tray.
l'_1 = limiting moles per hr of a heavy component in the liquid from a tray between the feeds of a two-feed tower.
L = moles per hr of liquid falling from a rectifying tray.
L' = moles per hr of liquid falling from a stripping tray.
L_o = limiting moles per hr of the combined keys in the liquid from a tray in the rectifying section.
L_o' = limiting moles per hr of the combined keys in the liquid from a tray in the stripping section.
$(L_o)_1$ = limiting moles per hr of the combined keys in the liquid from a tray between the feeds of a two-feed tower.
s = moles per hr of a component in a sidestream product.
S = moles per hr of a sidestream product.
v = moles per hr of a component in the vapor from a rectifying tray.
v' = moles per hr of a component in the vapor from a stripping tray.
v = limiting moles per hr of a light component in the vapor from a rectifying tray.
v_1 = limiting moles per hr of a light component in the vapor from a tray between the feeds of a two-tray tower.
v' = limiting moles per hr of a heavy component in the vapor from a stripping tray.
v'_1 = limiting moles per hr of a heavy component in the vapor from a tray between the feeds of a two-tray tower.
V = moles per hr of vapor rising from a rectifying tray.
V' = moles per hr of vapor rising from a stripping tray.
V_o = limiting moles per hr of the combined keys in the vapor from a rectifying tray.
V_o' = limiting moles per hr of the combined keys in the vapor from a stripping tray.
$(V_o)_1$ = limiting moles per hr of the combined keys in the vapor from a tray between the feeds in a two-tray tower.
x_o = mol fraction of the light key in the combined keys, considered as a binary system.
α = relative volatility.
α_{AB}, α_{CD} = volatility of A relative to B (or of C to D).

Subscripts

B = net bottoms product.
D = net overhead product.
f = feed tray.
f+1, f+2 = position of tray above the feed tray.
f − 1, f − 2 = position of tray below the feed tray.
F = feed.
i = section between the feeds of a two-feed tower.
lk = light key.
hk = heavy key.
r = reboiler.
0, 1, 2, 3 = tray number, starting from the top or from the bottom.

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Unique design . . .

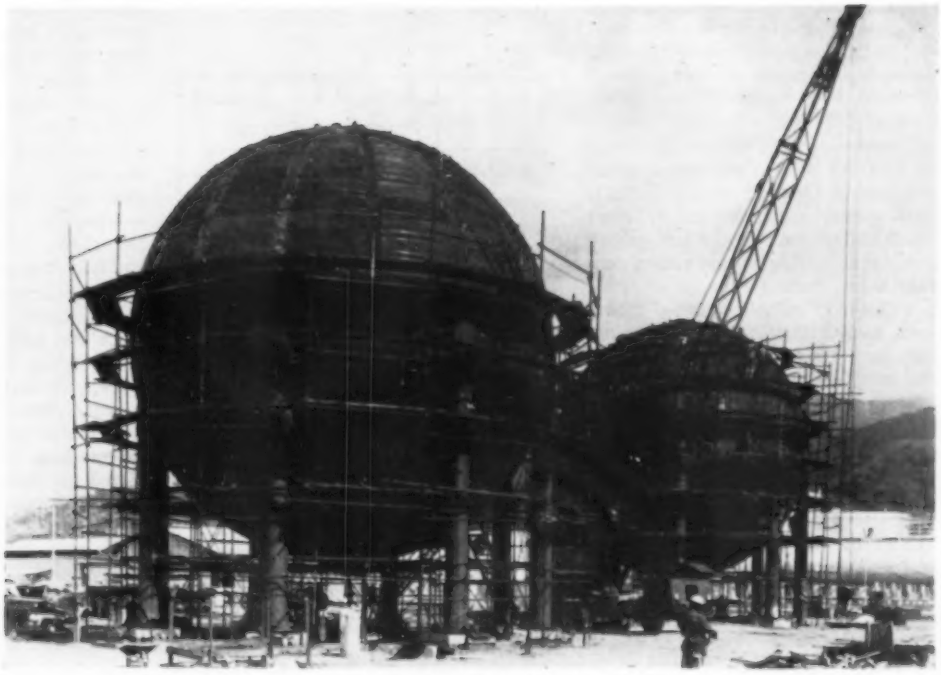

FIG. 1. Metal thickness for giant propane storage spheres at Compania Shell de Venezuela's No. 1 Depot in Catia de la Mar.

Spherical Tanks used for Propane in Venezuela

Guillermo Esnal
Compania Shell de Venezuela
Caracas

World's largest propane storage vessels hold 7000 bbl at 235 psi design pressure

GROWTH in the use of propane throughout the world has been extraordinary for the past quarter century, and in Venezuela it offers outstanding prospects to the country's economic advancement. Distribution of propane requires, of course, the use of storage tanks that will withstand the pressure of liquid propane, normally a gas under ordinary conditions of pressure and temperature.

The more usual type of storage tank for liquefied propane is the cylindrical vessel, mounted either horizontally or vertically. However, the spherical tank is particularly interesting, due to its efficiency and economy.

Structurally, for a given thickness, the spherical shape permits the withstanding of higher internal pressures than any other shape. Also, for a given storage volume, it requires less land area than any other shape. And, of course, there is a lesser area of external surface to be insulated, painted, and maintained than any other shape.

It is known that, for a given internal pressure, the tank's diameter can be increased only with a corresponding increase in the thickness of the steel plate. The increase in diameter, in order to achieve a larger storage capacity, and the practical limitation on thickness, for constructive reasons, are contradictory. The only possible solution lies in the use of steel of greater strength.

This has been attained with the use of a new alloy "Carilloy," having a strength nearly double that of steel normally used in tank construction. Taking advantage of this new material, in 1956 Compania Shell de Venezuela built two spherical tanks for propane storage at its No. 1 Depot in Catia de la Mar.

Prior to this time, only in Japan had spherical tanks been constructed with

"Carilloy." Those tanks have larger storage capacities, but can withstand only about half the pressure designed for the Venezuelan tanks. Designed to withstand 16 atmospheres (235 psi), the Venezuelan tanks are therefore the largest high-pressure storage tanks in the world. Each holds 1100 cu meters, or about 6920 bbl.

Diameter of each tank is 12.80 meters (42 ft) with a maximum metal thickness of only 32 mm (1¼ in.). Each sphere is supported by eight cylindrical columns placed underneath its equator, resting on individual concrete bases. Each column is designed to withstand, without relative movement, a load of 162 tons. This maximum load is based on filling the sphere with water for pressure testing.

In the design of pressure tanks for liquid propane storage, criteria are generally determined by standards and codes emanating from institutions related to the subject. Nearly all specifications regard vapor pressure of propane as the important characteristic in designing thicknesses and sections. In addition, a safety factor is provided to guard against high fluctuations in pressure and temperature, particularly where fire is a potential hazard.

Refrigeration of the propane would reduce the pressure in the tanks. In small installations, however, such a solution would be more expensive. Thus preference is given to construction of larger pressure tanks operated at ambient temperature.

General Description of Spheres

The sphere with which we are concerned is formed by two basic constituents: An internal capsule built up of plates having a maximum thickness of 1¼ in. of a special steel alloy called "Carilloy T-1" to which the corresponding sphericity has been given prior to their being welded together, and covered with insulating material consisting of 2 in. of mineral fiber, ½ in. of cement capable of resisting high temperatures, a protective covering against outdoor conditions and, finally, a coat of paint.

Bearing in mind the special heat treatment that the tank has to undergo after erection, a supporting mechanism at the foot of the columns was designed, formed by a plate fixed to the base pedestal and another plate fixed to the column. These plates can slide over one another, thus preventing the transfer of horizontal stresses to the bases during the heat treatment. As the steel of the tank has to be heated to 600 C and then allowed to cool gradually, displacements of up to 5.4 centimeters may occur; if such displacements were interfered with, internal stresses dangerous to the structure would be created.

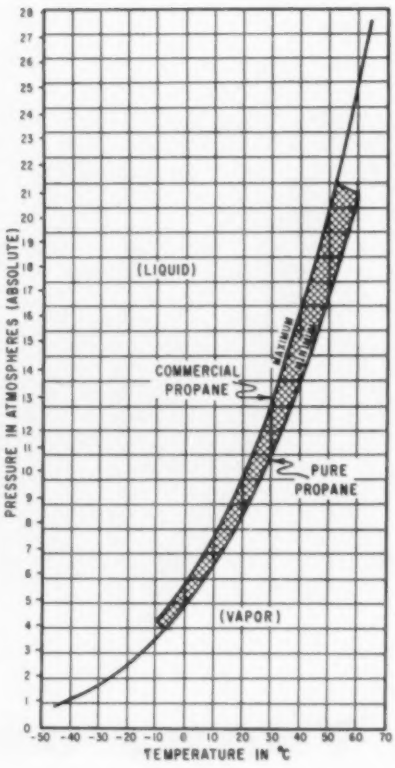

FIG. 2. Vapor pressure of pure and commercial propane.

Special "Carilloy" Alloy

Each of the spheres has a capacity of 1100 cu meters and a diameter of 12.80 meters. To withstand an internal pressure of 16 atmospheres, normal ASA No. A.30 steel would have necessitated a thickness of 2½ in. As the tanks were erected on the spot, such a thickness would have made heat treatment difficult and prevent elimination of internal stresses after welding. Furthermore, construction and transportation considerations favored use of a thickness not exceeding 1¼ in.

Tests were made to select the most appropriate electrodes for welding the "Carilloy" sheets together. To achieve high resistance in the areas affected by heat without creating excessive internal stresses, "Atom Arc E11016" electrodes were chosen, and they were oven-dried before use. All welds were thoroughly inspected by X-ray to correct possible flaws or defects.

"Carilloy T-1" steel acquires part of its unusual properties through a special heat treatment. After cutting the sheets and preparing their edges for welding, the steel was oven-heated to 900 C and then water-cooled. After erection and welding the well-insulated tank was heated for an hour to almost 600 C, and cooled gradually.

The tank was insulated with a mineral fiber layer prior to heat treating it. Once the tank cooled, the insulation covering the welds was removed (on an approximate width of 30 centimeters,) before proceeding with the hydrostatic test, in order to permit examination. Once the test was completed the layer of insulation was put back in place.

Soil and Foundations

Total weight of each spherical tank, with its layer of insulation, columns, bases, and fixtures, is approximately 200 tons. Weight of 1.100 cubic meters of propane (specific gravity 0.51) is 560 tons, thus the resultant normal load is 760 tons. Each of the eight foundations thus represents an approximate load of 95 tons. However, because testing of the tanks was with water, it was necessary to consider an overall load of 200 (tank) + 1100 (water) = 1300 tons, which works out to 163 tons per column.

The magnitude of such loads and the poor superficial characteristics of the soil made it imperative to conduct a complete and exhaustive exploration of the soil. It had to be taken into consideration that the bases for a tank of the proposed dimensions had to be isolated, as called for by economical reasons and simplicity of design. And a solution regarding the bases presupposes establishment of very accurate criteria concerning possibilities of differential settlings, and consideration of the fact that a tank which is to contain a product of the aforementioned characteristics, subjected to strong internal stresses, cannot be exposed to distortions of a fairly large degree resulting from movements at the bases.

Subsoil Findings

Soil bearing and core tests showed that the subsoil in the tank erection area is constituted by deposits of variable thickness formed by *superimposed layers* almost alternating with sands and silts, the latter containing sands in small quantities and being plastic only to a small extent; the sands in turn show varying degrees of grading, rang-

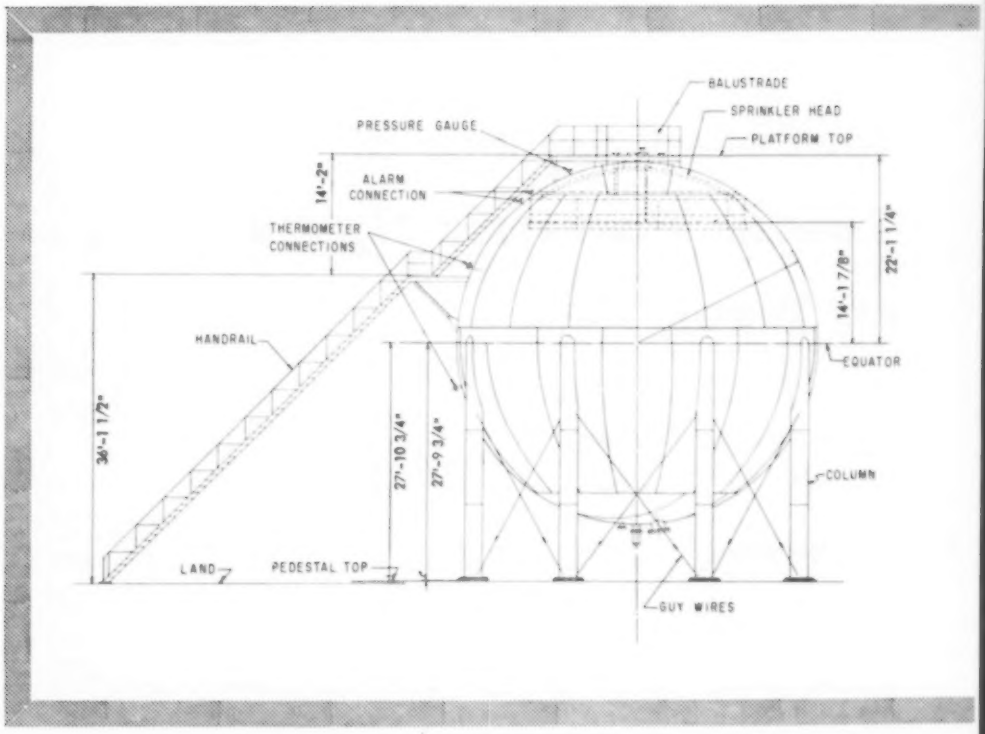

FIG. 3. Elevation drawing of propane storage sphere.

ing from very tiny grains to decidedly coarse ones. In the area where exploration work was carried out there exists a superficial layer formed by a fill 1.5 meters thick. As depth increases, sand compactness grows and consistency of silts also becomes greater.

Design of Pilings

Bearing in mind that the supporting capacity of the soil investigated is larger as depth increases, a very convenient solution was worked out — represented by slabs resting upon piles.

Absence of a hard layer, such as rock or some similar material, within reasonable depth limits, determined beforehand the working condition for piles, which are supported by friction. This made the driving of such piles compulsory, instead of pouring them on the spot or resorting to some other equivalent method.

Since the test-load per column is 162 tons, choice of the number of piles depended on a balance of economical and safety factors.

If the number of piles were great, their length might have been uneconomical, due not only to the cost of the piles in itself, but also to the dimensions which would be required in the slab for each foundation. On the other hand, a very low number of piles would call for an increase in their length, with a relatively low overall efficiency of the assembly, owing to the fact that common diameters of driven-in commercial piles show very little variation one from another, which means that to achieve an acceptable support, the lengths must be increased.

These and other reasons finally led to the establishment, as a very convenient number, of six piles weighing 30 tons each, to each base, which could be arranged on the ground in two different formations, bearing in mind the optimum spacing, as indicated below:

a. Rectangle-wise, with two parallel lines of three piles each;
b. Five piles forming a regular pentagon, and one central pile.

The advantages and shortcomings of the two solutions may be summarized in a few words. The rectangular arrangement simplifies operations of reinforcement and plank cutting, but substantially increases the section; on the other hand, the lay-out in the form of a pentagon, even though it increases work and makes planking a little bit more complicated than for a rectangular lay-out, permits of substantially smaller sections and better positioning of the piles, and furthermore makes for a very desirable overall symmetry. Since for a structure as the one described this is yet another safety factor the second solution was chosen, i.e., five "step-taper" piles forming a pentagon and one central pile.

Foundation Slabs

Each of the tanks is thus supported by 48 piles, which distributed in groups of six, arranged as previously indicated, five of them forming a regular pentagon, plus a central pile.

The interlocking slab between the column and the head of the piles was calculated in the customary manner, assuming the piles to be concentrated loads applied at the extremity of a corbel. Soil reaction underneath the slab was disregarded, bearing in mind that the settlements in superficial layers under great loads are much greater than those that would be allowed, in general, by the piles to the slab.

The support itself was formed by a slab 80 centimeters thick, of a pentagonal shape, resting on the piles and receiving the column-load via a pedestal 35 centimeters high and having a surface of 1.27 square meters.

The slab was assembled with a grid formed by bars ¾ in. in diameter and spaced 7.5 centimeters apart. Additional reinforcements were provided against temperature and other causes, both at the pedestal and at the upper plane of the slab.

The eight units forming the tank's supporting system are interconnected by a bracing girder, whose main object is to absorb horizontal movements of the slabs, such as, for example, those caused by fluctuation in the tank loads. For the same reasons a bracing system made up of bars welded to the heads of the piles at each slab has been provided. ★ ★ ★

Controlled Settling of Tank Foundations on Weak Soils

Compacted fill and gradual loading eliminates need for piling, saves $100,000 per tank

John Martinson

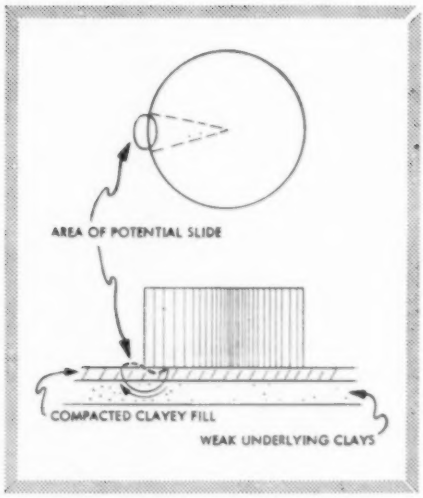

FIG. 1. Mechanics of possible soil failure, showing the direction of forces that must be resisted to prevent shearing.

ERECTED over extremely weak clay soils, two large storage tanks were recently completed at Tidewater Oil Company's Avon refinery near San Francisco without the use of piling, ring wall, concrete pad or other conventional foundation materials. This construction method resulted in a saving of about $100,000 per tank, the cost of piling that would ordinarily be used under the same soil conditions. These tanks are part of an expansion of the refinery now being done for Tidewater by the Bechtel Corporation of San Francisco.

Scope of the Project

Storage tanks are a floating roof type, 140 ft in diameter and 48 ft high, 131,000 bbl capacity. Site of construction is in the tidal marshlands near the mouth of the Sacramento River. Preliminary soil investigations of the site were made by Dames and Moore Soils Engineers. Their report showed that beneath the immediate surface which was peat, or clay with lenses of peat, there was a series of weak clay deposits up to 6 ft in thickness. Shear resistance of these deposits was on the order of only 200 to 300 lb per sq ft. Laboratory tests were made on representative core samples to determine shear strength, consolidation characteristics, moisture content, and density. It was suggested by Dames and Moore that if appreciable settlement of the tanks could be tolerated, it would be possible to consolidate the underlying soils by proper placement of a compacted fill and gradual loading of the tank itself. This construction method was followed during the months it took to erect and fill the tank.

Compacted Clayey Fill Meets Job Specifications

A compacted clayey fill was placed 10 ft thick to underlie the tanks and extend 30 ft outside the perimeter of the tanks. This fill was necessary to prevent a shear failure of the soils underlying the tanks. Fill would have been necessary even if piling had been driven in order to bring the tanks elevation in line with the rest of the plant. Any rupture in the fill would have caused serious failure of the entire structure. Original specifications called for compaction to 95 percent of maximum density by the modified AASHO method. After laboratory tests of core samples of compacted fill it was found that 90 percent compaction was sufficient. A minimum shear strength of 1000 lb per sq ft was attained.

On the basis of the initial test borings it was expected that the weight of the fill would cause a subsidence of approximately 24 in. during the next 20 years, the first 6 in. to occur during the filling operation. In that same period it was predicted that there would be an additional 12 in. subsidence at the center of the tanks and 7 in. at the edge, due to the loading of the tanks.

Mechanics of possible soil failure

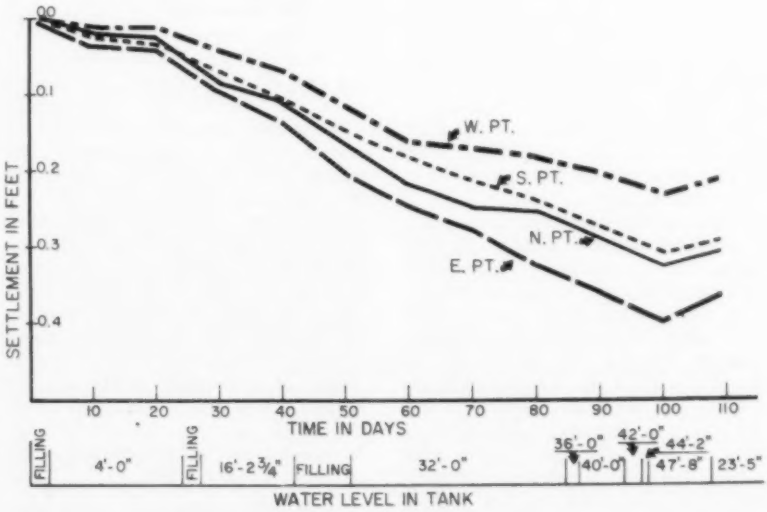

FIG. 2. Settlement of Tank 651 was about the same in each quadrant, caused no problems.

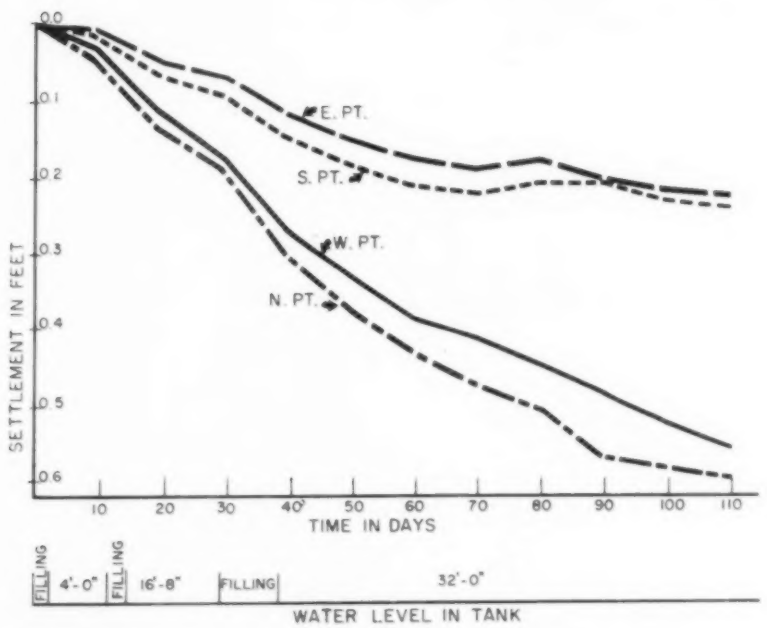

FIG. 3. Re-leveling corrected uneven settling of Tank 650, was still far cheaper than piling would have been. The tank was apparently built on the site of an old stream bed.

are shown schematically in Fig. 1. If the supporting soils received a load of sufficient weight the result would be shear failure along a curved failure surface. It can be seen from the schematic drawing that the shear surface passes through the compacted fill and the weak underlying soils. Underlying soils are strengthened by consolidation or the process of squeezing water out and reducing the void space.

Even if there were no failure of soil, another problem that could arise is lateral flow. Lateral flow would mean that a strata of soil some distance below the surface would move in a horizontal direction instead of undergoing true consolidation. If lateral flow occurred the tanks would settle at a more or less constant rate, while true consolidation is marked by a decreasing rate of settlement during each increment of load.

Four Weeks Required To Fill New Tanks

After placing of the fill and erection of the tanks gradual loading of the tanks with water was begun. Test loading of the tanks and subsequent controlled settlement took place over a period of several months. Rate of settlement for each tank is shown graphically in Fig. 2 and 3. Tank 651 was filled to a height of 4 ft and maintained for 3 weeks. Then over a 3-day period it was gradually filled to a height of 16 ft imposing a load of approximately 1000 lb per sq ft on the bottom of the tank. Elevations were taken at quarter points on the tanks, daily for the first week after filling and then weekly. After 15 days with the water level at 16 ft, there was a 9-day period of gradual filling bringing the water level to 32 ft or approximately 2000 lb per sq ft. For slightly over a month water level was maintained at 32 ft. Then over a 2-week period the level was raised in stages to 48 ft, maintained for 2 weeks and then lowered to 23½ ft. Settlement was satisfactory at all points.

Essentially the same filling procedure was used in loading Tank 650 up to the time the 32 ft level was reached. By that time, as Fig. 3 clearly shows, a differential settlement had developed. The north and west points were settling more than the south and east points. Before correcting this differential settlement additional soil tests were made on core samples taken near the perimeter of the tank at the points of maximum and minimum settlement. The log of these test borings and subsequent laboratory tests indicate that the thickness of the weak underlying soils differed considerably in their natural state. At the point of maximum settlement there was at least 4 ft of weak clays while the same soil was 6 in. to 1 ft thick at the point of minimum settlement. It appears likely that the site of Tank 650 was at one time a stream bed.

Re-Leveling Corrects Uneven Settling

Tests on samples taken at points of minimum and maximum settlement indicated that the point of minimum settlement would probably settle only 1 in. in the next 20 years while the point of maximum settlement could be expected to settle 24 in. in the same time. Since a differential settlement of this size would endanger the functioning of the tank and floating roof mechanism, the low side of the tank was jacked an additional 6 in. beyond the distance necessary for present re-leveling. After re-leveling the tank test loading was completed and it was put into operation. Bechtel engineers expected at least 5 years use of the tank before a second re-leveling might be necessary. Cost of re-leveling was approximately $10,000 so even with the possible cost of another re-leveling the savings on these

FIG. 4. Typical view of the marshlands before the fill operation and tank construction.

FIG. 5. Tank 650, showing asphalt berm and brackets used to lift tank with hydraulic jacks.

two tanks is upwards of $175,000.

Re-leveling was accomplished by a combination of conventional hydraulic jacking and mud jacking. Before re-leveling the roof was lowered to within several feet of the tank bottom and supported at the center, midway and at the edges. Brackets were welded to the outside of the tank at a number of points around a 270 deg section of the tank. The brackets provided a surface against which the hydraulic jacks could lift the tank. Lowest point was raised 18 in. or approximately 6 in. above true level in order to compensate for future settlement. With the perimeter of the tank raised 18 in., an asphaltic concrete berm was then placed around the bottom of the tank on which the base rested, when the jacks were removed.

After the berm was in place sealing off the underside of the tank the mud jacking was started. Hoses were attached to openings in the tank bottom from inside the tank. Grout was then intruded through the hoses under considerable pressure. With the berm sealing off the sides, the pressurized grout acted like a large hydraulic lift, raising a great area of the tank bottom and providing a firm base for it.

FIG. 6. From marshland to tank farm. Tank 651, completed and in use.

Careful Engineering Eliminates Most of Risk

Other tanks have probably been built on weak soils by similar methods before, but the soils engineers believe these tanks to be among the largest ever erected by this method. In the concept of the method of support for these tanks marginal factors of safety were involved. However, careful soil investigating and engineering before and during construction virtually eliminated the element of chance, and demonstrate what can be accomplished because of the advances that have been made in the ever growing field of soil engineering. ★ ★ ★

P 791.22

new

N-Oleoyl sarcosine protects tanker bulkheads, pipelines, and tanks, may benefit motorists, too

Gasoline Rust Inhibitor

Robert M. Pines and Dr. John D. Spivack

Research Laboratories, Geigy Chemical Corporation, Yonkers, New York

THE CORROSION problems encountered in processing, transportation, and storage of refined petroleum products such as gasoline and kerosine have long been of prime concern to the petroleum industry. Corrosion costs of up to $150,000 per T2 marine tanker per year have been reported for those vessels in clean service. Pipeline, storage and mixing tank costs are similarly high.

A good method for the mitigation of these losses is the incorporation of an effective corrosion inhibitor into the hydrocarbon. Such an agent incorporated at the refinery would serve to protect pipelines,[2] the bulkheads of marine tankers,[3] and storage tanks. Any other ferrous surface contacted by the fluid would be similarly protected from rusting.

N-Acyl amino acids have previously been shown to have effective rust inhibiting properties in mineral lubricating oil solution.[1] Among the most effective of the compounds studied are the fatty acyl derivatives of sarcosine.

N-Oleoyl sarcosine,[1] because it is a liquid at room temperatures, readily soluble in light hydrocarbons, and ashless upon ignition, in addition to its excellent performance properties under a variety of rust inducing conditions, is particularly suitable for incorporation into gasolines. The physical properties of N-Oleoyl sarcosine are summarized in Table 1.

The conditions under which gasoline is transported and used make it advisable that a rust inhibitor designed for this type of service be effective under (a). dynamic conditions where the gasoline and water phases are being continuously mixed, and (b) under static conditions where the two phases are allowed to separate, such as in tank storage.

Under both types of conditions it is desired that the inhibitor be rapidly and tenaciously adsorbed on the metal surface so that a relatively impervious protective film be formed. Static conditions are much more conductive to rusting unless the inhibitor film is highly resistant to leaching by water.

Gasoline solutions of N-Oleoyl sarcosine were, therefore, tested by a variety of methods, both static and dynamic, adopted by government and industry for use in evaluating the rust inhibiting properties of light hydrocarbons. Auxiliary tests were also applied to determine the effect N-Oleoyl sarcosine might have on other properties of some of these products.

Laboratory studies of the rust preventive properties of N-Oleoyl sarcosine were run in a straight run gasoline containing no additives or dye.

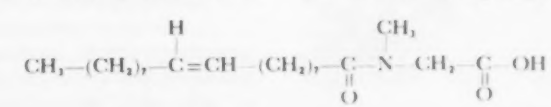

FIG. 1. N-Oleoyl sarcosine.

Dynamic Immersion Test

(Method ASTM D665-54[4] Modified)

The test was modified to run at 80 F for 3 hours with synthetic sea water[4] and was designed to evaluate the rust

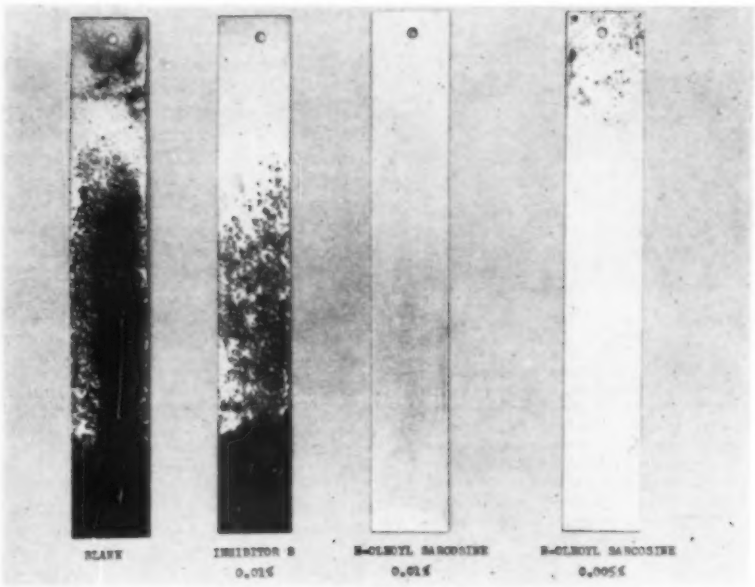

FIG. 2. Static test of N-Oleoyl sarcosine in gasoline. The steel test strips were exposed for three weeks at room temperature to 100 ml of ASTM synthetic sea water, 750 ml of inhibitor-containing gasoline, and the vapor phase.

preventive properties of inhibited gasoline when both the aqueous and hydrocarbon phases are intimately stirred and both are in contact with the entire immersed portion of the SAE 1020 steel test cylinder. The same test was also run on inhibited gasoline which had been subjected to a water extraction with 10 percent by volume of distilled water. Comparative tests run with a commercial inhibitor (Table 2), demonstrate that N-Oleoyl sarcosine is a more effective inhibitor, especially in its ability to resist extraction by water.

Static Immersion Test

This test,[5] which is run under essentially quiescent conditions, simulates those found in marine tankers during the cargo run and in storage tanks.

A 6½ by 1 by 1/32 in. SAE 1010 cold-rolled steel strip cleaned and finished with 5/0 sandpaper is partially immersed in 100 ml of ASTM synthetic sea water and 750 ml of gasoline contained in a one quart jar. The system is thoroughly shaken for one minute and then set aside in the dark for three weeks at room temperature. The specimen is then removed, examined and rated by the system described in Table 2.

Table 3 indicates the unusual effectiveness of N-Oleoyl sarcosine in preventing corrosion of the steel exposed to the aqueous phase.

The elimination of rusting of test specimens immersed in gasoline solutions of N-Oleoyl sarcosine compared to identical specimens immersed in a gasoline solution of another inhibitor (Inhibitor S) and to a control test, in which no inhibitor was used, is shown in Fig. 2. Increase of the concentration of N-Oleoyl sarcosine from 0.005 to 0.01 percent practically eliminates corrosion of that portion of the test specimens exposed to the vapor phase.

Reverse Cycling Test

This test was devised to simulate conditions in a marine tanker through one complete cycle in which the bulkheads are filled first with refined cargo, then are either ballasted with seawater or maintained empty for the return trip. Tests similar in principle, if not in detail, have been used by others.[6]

Tared, sandblasted specimens of SAE 1010 cold-rolled steel, 1 by 2 by 1/32 in. in size are rusted by immersion in synthetic sea water for four days. They are air dried for one day, reimmersed in synthetic sea water for one day and finally air dried for one day more. This produces an adherent relatively uniform rust coating. The specimens are wetted in synthetic sea water and totally immersed in the test gasoline for one week at room temperature. They are then removed and half the number of specimens are totally immersed in synthetic sea water for one week more. The rest of the steel strips are suspended from a rack which is rotated slowly over synthetic sea water contained in a covered dessicator jar. Finely dispersed air is blown through the sea water so that a spray collects on the specimens and drips from them as they rotate. After one week at room temperature all the specimens are removed, brushed well and cleaned in inhibited acid. They are reweighed and percent protection calculated from the following equation.

$$\text{Percent protection} = 100 \times \frac{\text{wt loss uninhibited} - \text{wt loss inhibited specimen}}{\text{wt loss of uninhibited specimen}}$$

The test results (Table 4) emphasize the severity of the sea water spray test compared to the sea water immersion test, and the superiority of N-Oleoyl sarcosine in both systems compared to the commercial inhibitor.

The dynamic, static, and cycling corrosion tests all demonstrate the rust preventive properties of gasoline solutions of N-Oleoyl sarcosine under a variety of corrosive conditions. Addi-

TABLE 1 — Physical Properties of N-Oleoyl Sarcosine.

Setting point	32 F
Viscosity at 100 F	1180 SUS (255 CPS)
Color (ASTM)	3
Residue upon ignition	None
Specific gravity	0.948
Molecular weight	340-350
Solubility at room temperature	
In paraffin oil*	Infinite
In kerosine	Infinite
In Stoddard solvent	130 gms/100 gms
In water	Insoluble
Stability of 1% solution in paraffin oil at 12 F for 8 months	Clear

*Solvent-extracted mineral oil of 182 SUS at 100 F.

TABLE 2 — Results of Modified ASTM D665-54 Test
Inhibitors in Gasoline.

Inhibitor	Concentration wt %	Rating* Before extraction	Rating* After extraction
N-Oleoyl sarcosine	0.005	1	1
	0.0025	4	—
Inhibitor "S"	0.005	2	5
None	—	7	—

* — Rating System
1. Free of rust
2. Trace of rust, few spots
3. Less than 5% of surface rusted
4. 5-50% of surface rusted
5. 50-99% of surface rusted
6. Surface covered by light rust
7. Surface covered by heavy rust

† — Marine gasoline, no additives or dye.

TABLE 3 — Results of Static Immersion Test
Inhibitors in Gasoline.

Inhibitor	Concentration wt %	Rating* of SAE 1010 Steel impressed in Sea water	Gasoline	Vapor
N-Oleoyl sarcosine	0.01	1	1	1
	0.005	1	1	4
	0.0025	1	7	4
	0.001	5	6	5
Inhibitor "S"	0.01	7	4	1
None	—	7	6	6

*See Table II for rating system.
†Marine gasoline, no additives or dye.

TABLE 4 — Reverse Cycling Test
Inhibitors in Gasoline.

Inhibitor	Concentration wt %	Percent protection Specimens in sea water	Specimens in spray
N-Oleoyl sarcosine	0.0025	44	6
	0.0200	71	37
Inhibitor "S"	0.0025	13	0
	0.0200	19	6

*Marine gasoline, no additives or dye.

tional tests were run to determine the effect of the inhibitor on some other properties of engine fuels.

Solubility of Lead Salts

The lead salt of N-Oleoyl sarcosine was prepared by double decomposition of the sodium salt and lead acetate and was found to be soluble at room temperature in gasoline in the concentration range tested (up to 0.5 percent).

Water Tolerance of Aircraft Fuels

(ASTM D1094-53)[4]

This method[4] provides a procedure for determining the solubility of water in aviation gas and jet turbine fuels and involves shaking a sample of fuel with water at room temperatures and measuring the volume change of the aqueous layer. N-Oleoyl sarcosine apparently has no adverse effect on the solubility of water in gasoline and effects the emulsion properties only slightly (Table 5).

TABLE 5 — Water Tolerance — ASTM D1094-53
Inhibitor in Gasoline.

Inhibitor	Concentration wt %	Volume of water (5 min)	Remarks
N-Oleoyl sarcosine	0.01	20 ml.	slight lacy cuff
	0.005	20 ml.	slight lacy cuff
Inhibitor "S"	0.005	20 ml.	clean separation
None	—	20 ml.	clean separation

*Marine gasoline, no additives or dye.

TABLE 6 — Oxidation Stability — ASTM D525-55
Inhibitor in Gasoline.

Inhibitor	Concentration wt %	Time to fail (hours)
N-Oleoyl sarcosine	0.005	9
	0.0025	7½
	0	6

*Housebrand gasoline, additives and dye.

The Authors

R. M. Pines Dr. J. D. Spivack

Robert M. Pines is group leader of the Applications Group, Research Laboratories, and has done extensive work on the testing of corrosion inhibitors, metal chelates and surface active agents for aqueous and nonaqueous systems. A member of NACE, ACS, API and AATCC, he obtained a BA from Brooklyn College in 1944. After working for Valentine Company, National Lead Company, and New York City Board of Transportation, Pines joined Geigy Chemical Corporation in 1951.

Dr. John D. Spivack is a group leader in the Organic Research Laboratory and has done extensive work on the preparation and development of new organic compounds for use as corrosion inhibitors, metal chelates and surface active agents. A member of ACS, he obtained a PhD from McGill University in 1947. After working for Tidewater Oil Company for four years on lubricants research, Dr. Spivack joined Geigy Chemical Corporation in 1952.

Oxidation Stability of Gasoline

(ASTM D525-55).

Rust inhibitors have frequently acted as pro-oxidants in the catalyzed oxidation of hydrocarbon liquids. To study the effect of N-Oleoyl sarcosine, the inhibitor was dissolved in a less stable gasoline containing rust inhibitor, antioxidant, tetraethyl lead and dye. The data (Table 6) indicates that N-Oleoyl sarcosine had a marked stabilizing effect on the test gasoline.

Copper Corrosion by Petroleum Products

(ASTM D130-55T)[4]

N-Oleoyl sarcosine in gasoline at a concentration of 0.005 percent did not corrode or tarnish copper in the ASTM test.

N-Oleoyl sarcosine is an effective rust inhibitor in gasoline solution as demonstrated by a variety of tests, designed to simulate conditions, both static and dynamic, encountered in the transportation and storage of light hydrocarbons. In its resistance to water extraction and its effectiveness at low concentrations, N-Oleoyl sarcosine offers advantages over the commercially available inhibitor tested.

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2. Kleinhekscl, S., Lawrence, P. and Nelson, F., *Oil Gas J.* 53, 94-8 (1954).
3. a) Jupp, W. B., Soc. Naval Architects Marine Engrs. *Trans.* 60, 382-93 (1952).
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4. ASTM Book of Standards, Part 5, Fuels, Petroleum, Aromatic Hydrocarbons, Engine Antifreezes, 1955.
5. Socony-Mobil Research Laboratories, Private Communication.

★ ★ ★

P 729.1

Electron Microscope as an Analytical Tool

William H. Carls
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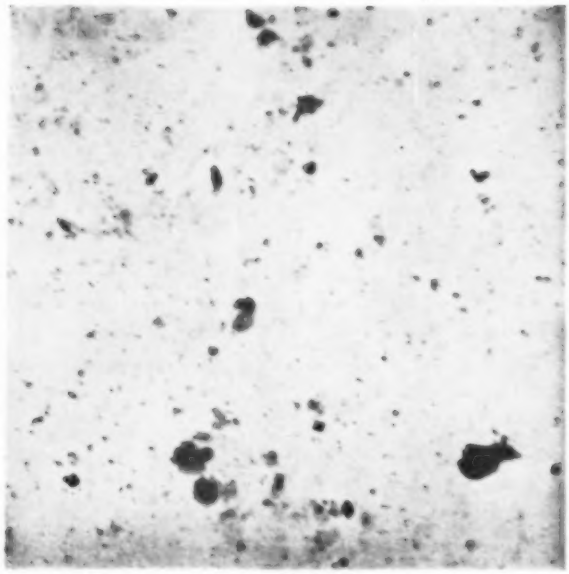
Effect of fuel oil additive is determined clearly and decisively with the aid of this impressive instrument

A primary problem in fuel handling systems is the formation of sludge and its accumulation. In both residual and distillate oils, it can clog strainers and filters, plug fuel lines, carbonize preheaters, interfere with proper atomization by destroying the spray pattern, and interfere with proper combustion in diesel engines by causing buildup on injector nozzles, cylinders, valves, and ports. It is the primary function of fuel oil additives to prevent or inhibit sludge formation and its accumulation. Also, they prevent corrosion in the fuel handling system, help inhibit post-combustion cororsion, and prevent water accumulation. In many instances, the proper use of additives makes it possible to use residual oils where either distillate fuels or blended oils were once the only feasible fuels.

Chemistry of Sludge Formation

Sludge is attributed to the precipitation of insoluble products of oil and the emulsification of these constituents with water. They may be normal components or the result of deterioration through oxidation and polymerization reactions. The oxidation reactions produce corrosive organic acids which, in turn, play an important part in the polymerization reactions which lead to formation of gum and "varnish"



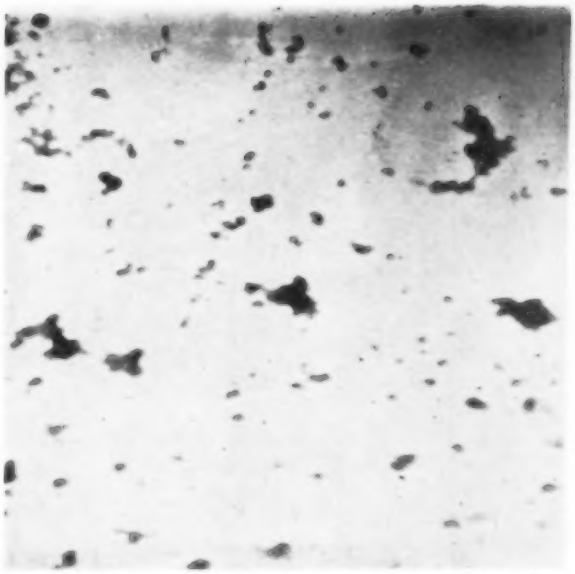


FIG. 1. (a) **Photomicrograph of unaged,** untreated diesel oil, as received from a supplier, showing asphaltene particles fairly uniformly distributed; and (b) **Showing an untreated,** unaged No. 6 fuel oil containing similar sludge-producing particles. Magnification, 11,600 diameters.

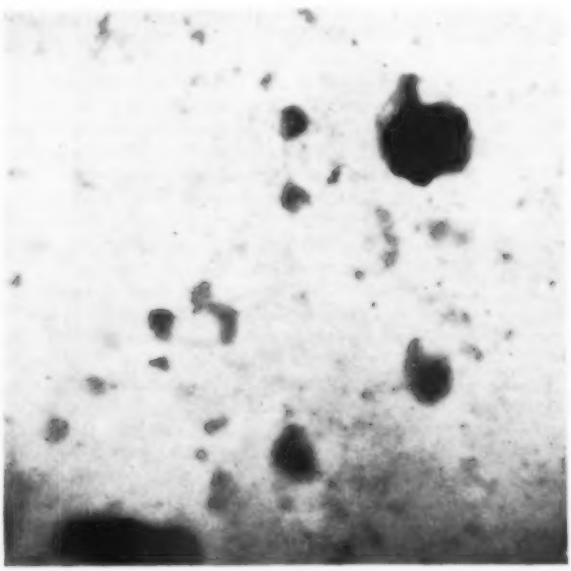
deposits.

The chemical characteristics of fuel oils have been divided into four major categories: Carboid fractions, asphaltenes, neutral resins, and "oil." The benzene-insoluble *carboid fraction* may be considered as a sediment consisting of elemental carbon compounds along with particles of inorganic debris, such as rust or scale. *Asphaltenes*, soluble in benzene but insoluble in pentane, consist of high molecular weight polycyclic hydrocarbons that form colloidal suspensions in the oil. *Neutral resins*, soluble in all petroleum fractions, are apparently a condensation product, one oxidation stage ahead of the oil itself and just behind the asphaltenes in this respect; their molecular weight is lower than the asphaltenes. Progressive oxidation of the *oil* produces these neutral resins. They in turn produce asphaltenes, followed, as a final step, by carboid formation.

The benzene-soluble asphaltenes play an important part in sludge formation apart from their carboid-formation tendencies. They also agglomerate as coatings on particles of benzene-insoluble dirt or sediment. One of the important actions of a fuel oil additive is to disperse these sludge-producing components, thus preventing their agglomeration. This applies both to light and residual grades.

Testing Additive Effectiveness

An accelerated aging program is often employed to test effectiveness of



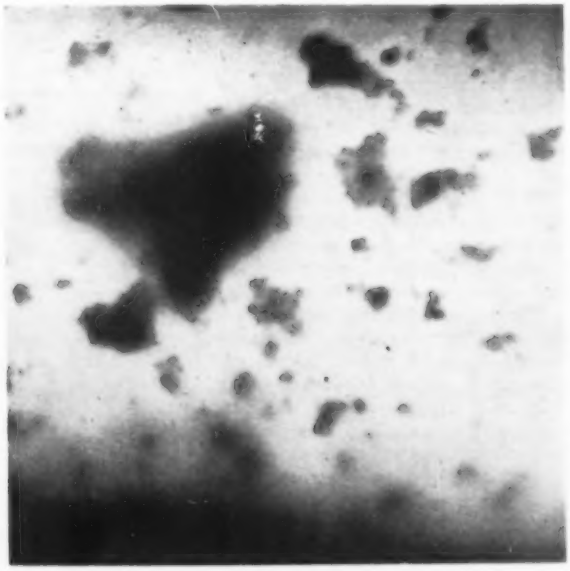


Fig. 2. (a) **Picture of an aged, untreated** diesel oil, after heating at 212 F for 48 hours, showing how heating has agglomerated the particles; and (b) **Aged, untreated No. 6 fuel** oil after being heated for one week, showing heavy agglomeration of sludge-formers. Magnification, 11,600 diameters.

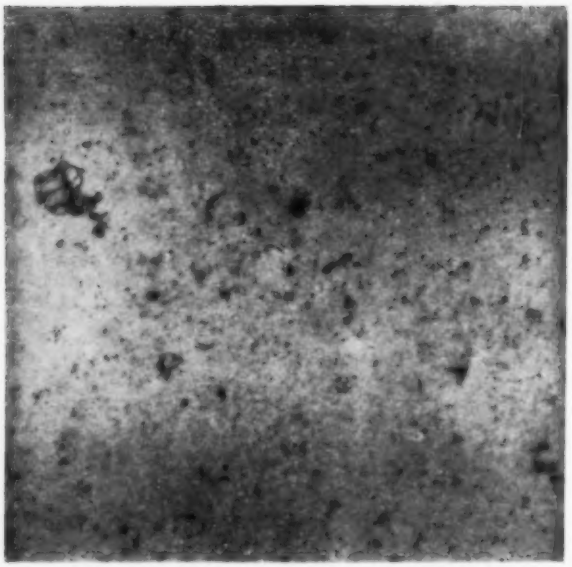


Fig. 3. (a) **Aged diesel oil, treated** with one part sludge-inhibiting additive to 4000 parts of oil. Particles have not grown, showing that sludge precipitation has not progressed; and (b) **Aged and treated No. 6 fuel** oil after receiving the same treatment as did the diesel fuel in 3 (a). Larger particles produced by aging have been broken up by the additive.

fuel oil additives in dispersant action and in inhibiting formation of insoluble residues. Samples of treated and untreated oil may be stored, open to the air, in an oven for 24 to 48 hours at 210 F, or until the untreated sample shows discoloration and the development of visible sediment. At the end of the test period, the samples are compared. An efficient additive, employed at an economical level of concentration, will maintain the oil in a clear condition, with little or no change in appearance.

It is relatively easy to measure qualitatively the results of this test in a light oil. One can readily determine the extent to which oxidation and polymerization has been reduced by visually comparing the two samples of aged light oil. Such comparison is impossible with a residual oil because of its color and consistency.

Electron Microscope

Through use of the electron microscope, however, it is a simple matter to determine the action of an additive even on a residual oil. The two series of illustrations compare sludge inhibition and dispersion in a catalytically cracked diesel oil and a residual oil. Both samples were subjected to an accelerated aging program in the presence and absence of an additive. All photomicrographs were taken at a magnification of 11,600 diameters.

The untreated, unaged samples were representative fuels that a consumer might obtain from an oil supplier, not "fresh" in the sense that they had just been produced by refining units. The oils had been centrifuged and filtered to remove tramp particles of scale, rust, and sediment. Such particles might otherwise have been mistaken for the sludge-producing ingredients, asphaltenes. The selective solvent employed in these tests was N-Hexane, in which asphaltene-type components are insoluble.

Fig. 1-a and 1-b show a photomicrographs of unaged, untreated diesel oil and unaged, untreated No. 6 (Bunker C) fuel oil. This is oil as received from a supplier. The sludge-producing ingredients are seen readily as small, and rather uniformly distributed particles throughout the oils.

Fig. 2-a and 2-b show photomicrographs of aged, untreated diesel oil and aged, untreated No. 6 fuel oil. The diesel oil was subjected to an accelerated aging program of 48 hours at 210 F. The residual oil was held at the same temperature for one week. In both samples the small, uniformly distributed asphaltene-type particles have combined into agglomerated masses. Further aging and oxidation would continue this agglomeration until precipation of sludge occurs. At the same time carboids, insoluble in benzene, would be produced by oxidation. These photos show sludge in the making. These particles are the culprits that ultimately cause clogging of strainers and filters, plugging of fuel lines, carbonization of preheaters, and interference with proper atomization by the buildup of varnish and lacquer deposits.

The last photographs, Fig. 3-a and 3-b, show aged, treated diesel and aged, treated residual oil. The same accelerated aging periods were used as in photographs 2-a and 2-b. Treatment consisted of one part additive in 4000 parts of oil.

These final results show that particle growth has been prevented by an additive. There is now no evidence of agglomeration. The sludge-producing structures have been maintained in a state of small particle size and their predominantly globular shape indicates that they occupy the smallest possible volume in relation to their size. The presence of additive has apparently broken up and dispersed the larger particles evident in Fig. 1-a and 1-b, and has reduced the particle size of the organic sludge-producing structures originally present in the oil. ★ ★ ★

The Author

Now supervising engineer charged largely with research and new product development for the Parolin Company, William H. Carls also supervises plant operations and technical sales-service. A chemical engineering graduate from Northwestern University Technological Institute in 1948, he graduated earlier from Wright College in Chicago, and has had 3½ years in the Air Force, largely in Europe. He recently completed a tour of Europe where he lectured to various groups on testing standards and fuel oil addition agents. He is a member of the American Chemical Society and other professional technical and scientific groups.

Tables Speed Cooling Tower Calculations

Maxey Brooke, *Old Ocean, Texas*

THE MECHANICAL draft cooling tower is one of the most neglected items of process equipment. They operate efficiently with little or no attention under wide variations of local conditions. No adequate theory of design or operation has been proposed. When cooling tower calculations are made, a series of rules-by-thumb is used.

One widely accepted rule-of-thumb is used in calculating the evaporation rate; **The evaporation is equal to one percent of the tower circulation rate for each 10 deg temperature drop through the tower.** This rule is based on the fact that the latent heat of evaporation of water is approximately 1000 Btu's per lb while the specific heat of water is 1 Btu per lb per deg F.

When this rule is used, it is assumed that all the heat is dissipated by the tower through evaporation of the water. No credit is given to the heat absorbed in raising the temperature of the air and water vapor drawn through the tower, i.e., the increase in sensible heat.

How to Calculate Evaporation Rate

By means of the accompanying tables and five temperature measurements, the true amount of water evaporated may be easily determined. The temperature measurements neccessary are:

1. Inlet (hot) water temperature.
2. Outlet (cold) water temperature.
3. Inlet air wet bulb temperature.
4. Inlet air dry bulb temperature.
5. Exhaust air temperature.

To set up a heat balance around a tower, it is only necessary to remember that the heat absorbed by the air is equal to the heat evolved by the water.

$$V(E_o - E_i) = L\,(T_i - T_o)$$

or

$$L/V = \frac{E_o - E_i}{T_i - T_o} = \frac{\Delta E}{R}$$

where

V = Flow of dry air through the tower, pounds per minute.
L = Flow of water through the tower (circulation rate), pounds per minute.
L/V = Liquid to vapor ratio.
E_o = Enthalpy of the inlet air-water vapor mixture at its wet bulb temperature, Btu's per pound of dry air.
E_i = Enthalpy of the outlet air-water vapor mixture at exhaust temperature, Btu's per pound of dry air.
ΔE = Enthalpy increase of the air-water vapor mixture flowing through the tower, Btu's per pound of dry air.
T_i = Temperature of the inlet or hot water, F.
T_o = Temperature of the outlet or cold water, F.
R = Cooling range of the tower, F.

The enthalpy of the air-water vapor mixture in the cooling tower temperature operating range can be calculated from the formula

$$\log_{10} E = 0.0112T + 0.07347$$

E = Enthalpy of the air-water vapor mixture, Btu's per pound of dry air.
T = Temperature, F.

But, it is more convenient to take the values from Table 1.

TABLE 1. Enthalpy of Moist (Saturated) Air.

T	E	T	E	T	E	T	E
35	13.01	65	30.06	95	63.32	125	136.4
36	13.44	66	30.83	96	64.92	126	140.1
37	13.87	67	31.62	97	66.55	127	143.9
38	14.32	68	32.42	98	68.23	128	147.8
39	14.77	69	33.25	99	69.96	129	151.8
40	15.23	70	34.09	100	71.73	130	155.9
41	15.70	71	34.95	101	73.55	131	160.3
42	16.17	72	35.83	102	75.42	132	164.7
43	16.66	73	36.74	103	77.34	133	169.3
44	17.15	74	37.66	104	79.31	134	174.0
45	17.65	75	38.61	105	81.34	135	178.9
46	18.16	76	39.57	106	83.42	136	183.9
47	18.68	77	40.57	107	85.56	137	189.0
48	19.21	78	41.58	108	87.76	138	194.4
49	19.75	79	42.62	109	90.03	139	199.9
50	20.30	80	43.69	110	92.34	140	205.7
51	20.86	81	44.78	111	94.72	141	211.6
52	21.44	82	45.90	112	97.18	142	217.7
53	22.02	83	47.04	113	99.71	143	224.1
54	22.62	84	48.22	114	102.31	144	230.6
55	23.22	85	49.43	115	104.98	145	237.4
56	23.84	86	50.66	116	107.73	146	244.4
57	24.48	87	51.93	117	110.55	147	251.7
58	25.12	88	53.23	118	113.46	148	259.3
59	25.78	89	54.56	119	116.46	149	267.1
60	26.46	90	55.93	120	119.54	150	257.3
61	27.15	91	57.33	121	122.72	151	283.6
62	27.85	92	58.78	122	125.98	152	292.4
63	28.57	93	60.25	123	129.35	153	301.5
64	29.31	94	61.77	124	132.8	154	310.9

T = Wet bulb temperature, F.
E = Enthalpy of air and its water vapor, Btu /lb dry air.

Sample Problem

For example, the temperatures measured are

Hot water temperature	105 F
Cold water temperature	89 F
Wet bulb temperature	78 F
Dry bulb temperature	88 F
Exhaust air temperature	97 F

From Table 1, the enthalpy of the inlet and outlet air are

$E_i = 41.58$ Btu's per lb of dry air.
$E_o = 66.55$ Btu's per lb of dry air.

$$L/V = \frac{66.55 - 41.58}{105 - 89} = \frac{24.97}{16} = 1.56$$

Thus 1.56 lb of water are circulated over the tower for each pound of dry air drawn through the tower.

If the tower circulation is 10,000 gal per min, the dry air used will be

$(10{,}000 \times 8.33) \div 1.56 = 53{,}400$ lb per min (1 gal of water weighs 8.33 lb).

Knowing the dry air flow through the tower and the water content of the inlet and outlet air, it is then possible to calculate the evaporation rate.

The moisture content of air at its dew point can be calculated, in the cooling tower temperature range, by the formula

$$\log_{10} H = 0.0150T - 0.867$$

H = Pounds of water per 100 lb of dry air
T = Temperature, F

or can be taken directly from Table 2.

When air is not at its dew point, its moisture content can be calculated by deducting 0.0229 lb of water per 100 lb of

The idea that works best for you

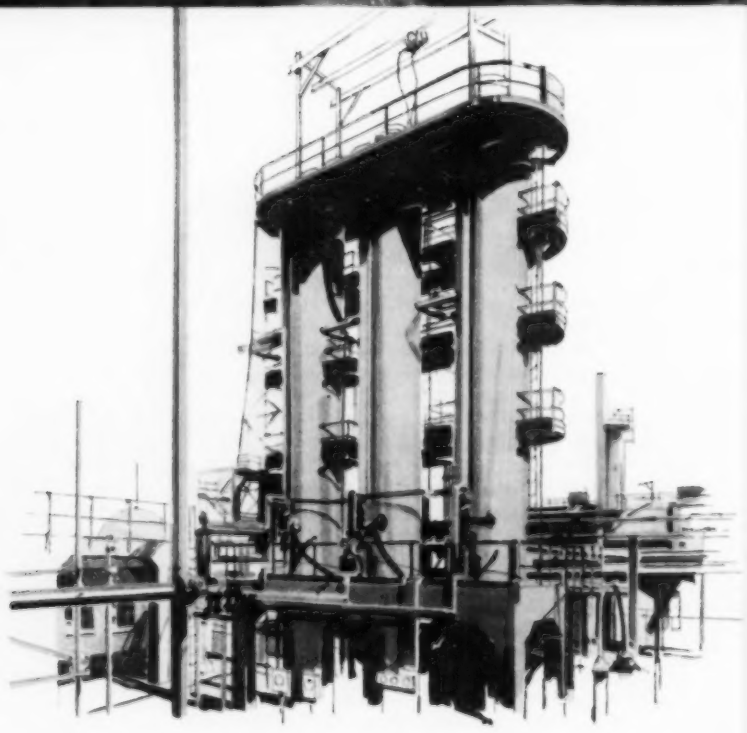


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TABLE 2. Humidity of Moist (Saturated) Air.

T	H	T	H	T	H
35	0.4275	65	1.326	95	3.673
36	0.4450	66	1.374	96	3.795
37	0.4631	67	1.424	97	3.920
38	0.4818	68	1.475	98	4.049
39	0.5012	69	1.528	99	4.182
40	0.5213	70	1.582	100	4.319
41	0.5421	71	1.639	101	4.460
42	0.5638	72	1.697	102	4.606
43	0.5860	73	1.757	103	4.756
44	0.6091	74	1.819	104	4.911
45	0.6331	75	1.882	105	5.070
46	0.6578	76	1.948	106	5.234
47	0.6835	77	2.016	107	5.404
48	0.7100	78	2.086	108	5.578
49	0.7374	79	1.158	109	5.758
50	0.7658	80	2.233	110	5.944
51	0.7952	81	2.310	111	6.135
52	0.8256	82	2.389	112	6.333
53	0.8569	83	2.471	113	6.536
54	0.8894	84	2.555	114	6.746
55	0.9229	85	2.642	115	6.962
56	0.9575	86	2.731	116	7.185
57	0.9934	87	2.824	117	7.415
58	1.030	88	2.919	118	7.652
59	1.069	89	3.017	119	7.897
60	1.108	90	3.118	120	8.149
61	1.149	91	3.223	121	8.410
62	1.191	92	3.330	122	8.678
63	1.235	93	3.441	123	8.955
64	1.280	94	3.556	124	9.242

T = Wet bulb temperature, F.
H = Humidity, pounds water per 100 lb dry air.
If air is not at its dew point, the humidity can be calculated by deducting 0.0229 lb of water for each degree difference between the dry and wet bulb temperatures.

dry air for each degree difference between the wet and dry bulb temperature. This is necessary only for the inlet air because the exhaust air of a properly operating tower will be saturated with water vapor.

In the example used . . .

Moisture content of inlet air at wet bulb temperature, 2.086 lb per 100 lb of dry air.

Difference between wet and dry bulb temperature of inlet air, 10 F.

Correction for difference between wet and dry bulb temperature of inlet air, $10 \times 0.0229 = 0.229$ lb per 100 lb of dry air.

Moisture content of inlet air, $2.086 - 0.229 = 1.857$ lb per 100 lb of dry air.

Moisture content of exhaust air, 3.920 lb per 100 lb of dry air.

Water evaporated, $3.920 - 1.857 = 2.063$ lb per 100 lb of dry air.

Total water evaporated, $\frac{53{,}400}{100} \times 2.063 = 1102$ lb per min, or $1102 \div 8.33 = 132$ gal per min.

By the rule of the thumb method, the evaporation loss would be $\frac{10{,}000}{100} \times \frac{16}{10} = 160$ gal per min, a 21 percent error.

One further example will illustrate the utility of the tables: In the operation of a cooling tower, no provisions were made to measure the makeup, blowdown, or circulation rates. Nevertheless it will be possible to calculate the following:

1. Blowdown rate,
2. Makeup rate,
3. Circulation rate,
4. Air rate,
5. Heat load.

The following temperature measurements were taken:

Hot water temperature	103 F
Cold water temperature	89 F
Wet bulb temperature	78 F
Dry bulb temperature	92 F
Exhaust air temperature	95 F

The following chemical analyses are known,

Chlorides in makeup water	78 ppm
Chlorides in circulating water	923 ppm
Phosphates in circulating water	35 ppm

Twelve pounds per day of a treatment containing 53 percent phosphates are fed to the circulating water.

From Table 1,

Enthalpy of exhaust air, 63.32 Btu's per lb of dry air.

Enthalpy of inlet air, 41.58 Btu's per lb of dry air.

$$L/V = \frac{63.32 - 41.58}{103 - 89} = \frac{21.74}{14} = 1.55$$

From Table 2,

Moisture content of inlet air at wet bulb temperature, 2.086 lb per 100 lb of dry air.

Correction for difference between wet and dry bulb temperature of inlet air, $14 \times 0.0229 = 0.321$ lb per 100 lb of dry air.

Moisture content of inlet air, $2.086 - 0.321 = 1.765$ lb per 100 lb of dry air.

Moisture content of exhaust air, 3.693 lb per 100 lb of dry air.

Water evaporated, $3.693 - 1.765 = 1.928$ lb per 100 lb dry air.

All the treatment in a cooling tower leaves it in the blowdown. Knowing the amount of treatment used and its concentration in the circulating water, it is possible to determine the amount of blowdown, thus,

$$\text{Pounds per minute blowdown} = \frac{\text{lb/day } PO_4 \text{ added} \times 1{,}000{,}000}{\text{ppm } PO_4 \times \text{min per day}} = \frac{12 \times 0.53 \times 1{,}000{,}000}{35 \times 1440} = 126.2.$$

The cycles of concentration undergone by the circulating water can be determined

$$\frac{\text{ppm chlorides in circulating water}}{\text{ppm chlorides in makeup water}} = \frac{923}{78} = 11.8.$$

The makeup rate is the blowdown rate multiplied by the cycles of concentration

$$126.2 \times 11.8 = 1489.2 \text{ lb/min.}$$

The evaporation rate is the difference between the makeup rate and the blowdown rate

$$1489.2 - 126.2 = 1363 \text{ lb/min.}$$

From this value, the air flow can be calculated,

$$\frac{\text{evaporation, lb/min} \times 100}{\text{evaporation, lb/100 lb dry air}} = \frac{1363 \times 100}{1.928} = 70695 \text{ lb per min.}$$

The water circulation rate equals the air circulation rate multiplied by the L/V ratio

$$70695 \times 1.55 = 109{,}574 \text{ lb per min.}$$

And the heat load is the circulation rate multiplied by the cooling range

$$109{,}574 \times 14 = 1{,}534{,}036 \text{ Btu's/min.}$$

The answers to the problem proposed are,

1. Blowdown rate, 126.2 lb/min or 15.2 gpm
2. Makeup rate, 1489.2 lb/min or 178.8 gpm
3. Circulation rate, 109,574 lb/min or 13,154.1 gpm
4. Air rate, 70,695 lb/min
5. Heat load, 1,534,036 Btu's/min.

* * *

Fuels and Lubricants for Tomorrow's Cars

Here's what the refiner can expect during the next several years

Dr. C. G. A. Rosen

AT no time in automotive history has there been such a wide frontal attack in exploring new ideas for power production as now. Three economic factors confront the engine designer with respect to fuels, (a) fuel availability, (b) fuel cost, and (c) specific fuel consumption. Motor gasoline is a primary force guiding developments in the refining of crude oil. The economics of petroleum refining poses the designer with another question — whether to design for economy by maximum performance of premium fuels or for the acceptable consumption of economy fuels.

The designer also will be influenced by a choice of maximum horsepower per cubic inch displacement or per cubic volume occupied. The relative cost of fuels is directly influenced by the law of supply and demand. It is axiomatic that certain combinations of power sources, fuel types and methods of utilization are best suited for each installation.

In the category of engines designed for maximum performance on premium fuels are those which include the high output aluminum engines operating on the Otto cycle with fuel injection. In the Diesel cycle they follow the modern trend toward quiet combustion systems, capable of operating on multifuels. In the bracket of engines burning economy fuels, advantages are gained by providing excess air through supercharging and high compression ratios to shorten ignition lag. This trend introduces the gas turbine in its various ramifications. Wherever the gas turbine is applied, whether it be in supercharging, as a component in compound power plants, or as an individual unit in itself, its application broadens an engine's appetite in the consumption of difficult fuel. The new engines are all part of an exciting, important and continuing search for better automotive engines.

Consultant to the Department of Defense on "Power Plants of the Future," consultant to the president of Caterpillar Tractor Company, consulting engineer for Richfield Oil Corporation, Past President of SAE, Honorary Fellow of ASME.

Adapted by the author from a paper presented to Western Petroleum Refiners Association annual meeting, San Antonio, Texas, March 1957.

Automotive trends can best be analyzed by reference to present petroleum production as indicated in Fig. 1. In 1955 gasoline represented 56 percent of production, distillate fuels 25 percent, residual fuels 17 percent and lubricating oils 2 percent. The demand for motor gasoline dominates the availability structure as well as the refinery techniques to meet market requirements.

Anti-knock Trend

The situation with respect to the trend in anti-knock quality in premium gasoline as sold in the United States is revealed in Fig. 2. Gasoline with available octane numbers of 97 are in response to the more recent appearance of 10:1 compression ratio passenger car engines. These engines are approaching one horsepower per cubic inch displacement with break mean effective pressures as high as 166 psi.

It is significant to note that in the last 10 years the horsepower per cubic inch of automotive engines has gone up almost two and one-half times. This has been accomplished with an increase in displacement of 27 percent and with only 11 point increase in octane number.

These achievements will be further enhanced in the near future by the introduction of the all-aluminum engines fitted with injection systems. The all-aluminum engine will permit cost reduction, somewhat increased horsepower per cubic inch, permit weight savings in engines and in cars (thus reducing inertia loads and braking problems), with some slight advantages in octane. The 12:1 compression ratio production engine is around the corner which will show a rise in efficiency of 16 percent over a 7:1 compression ratio engine.

Engines of the Future

In the race for position with other

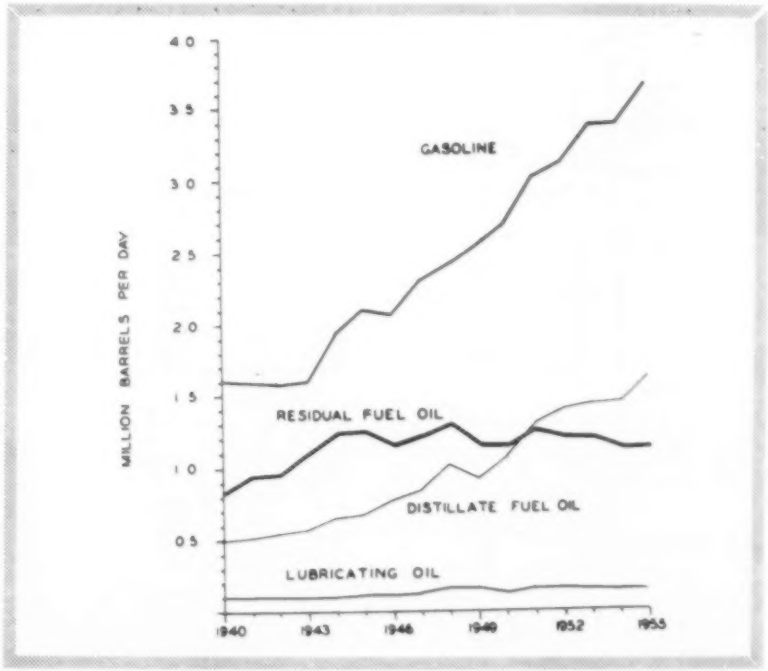

FIG. 1. Production of petroleum products in the United States.

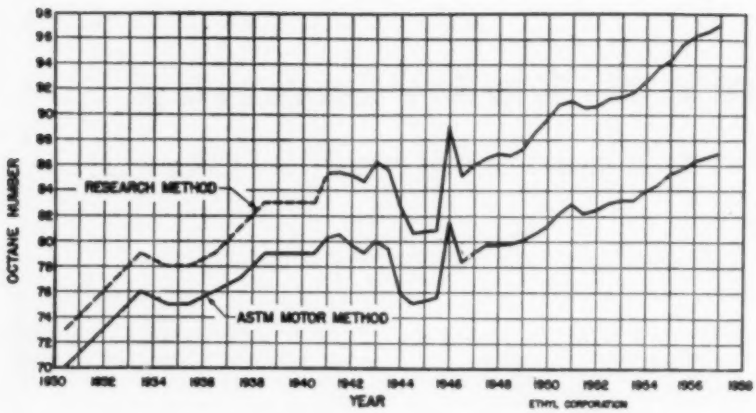

FIG. 2. Trend in anti-knock quality of premium gasoline sold in the U. S.

new power plants the piston engine presents a moving target, advancing in such a way as to make it more difficult for other power plant substitutions. The 12:1 compression ratio aluminum engine has shown gains which place it in an enviable position at the moment as compared with the gas turbine and free piston engine. Ideas projected by Caris of General Motors Research are shown in Fig. 3. Some designers of gas turbines and free piston power plants are more optimistic as to the possible future of the free piston engine and the gas turbine, but the piston engine is still in the running.

The higher compression ratios require higher quality gasoline. The present petroleum technology indicates a probable plateau at an octane number level of 108. According to W. M. Holaday: "Whether or not this quality can be produced economically is not yet known, but strictly from the process point of view, this is as high as can now be predicted."

New engines will bring into sharp focus the application of fuel injection as a replacement of the carburetor. There are five major reasons for this interest as expressed by Errol J. Gay:

1. A continuing demand for a higher peak horsepower.
2. A desire for a better torque curve at lower engine speed to improve the performance of modern automatic transmissions.
3. Styling changes forcing hood heights to be lower.
4. Under-hood temperatures require lowering.
5. The advertising value of a new device is significant.

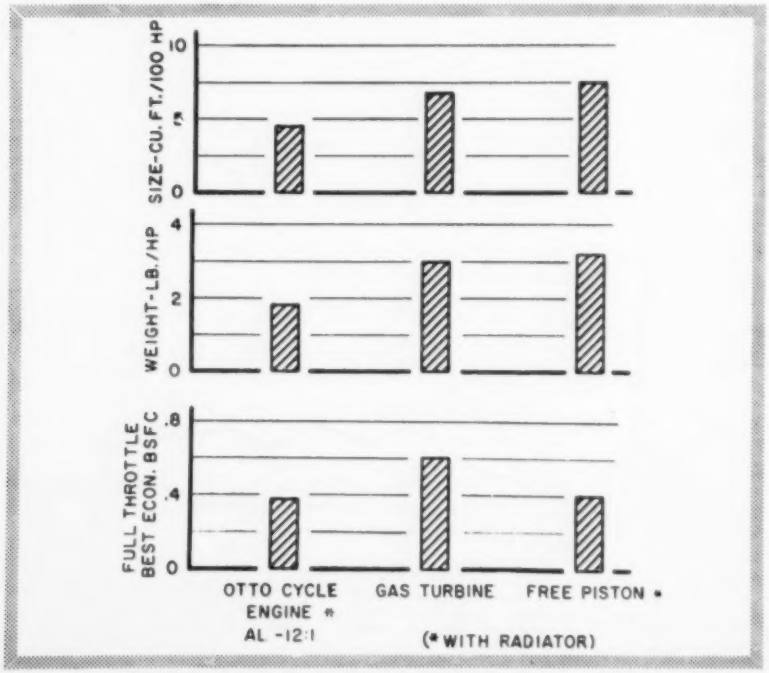

FIG. 3. Comparison of projected engine types.

Significance to the Refiner

From the petroleum standpoint there appears to be advantages worthy of mention. There should be in proper developed fuel injection systems almost complete freedom from icing troubles and back-firing during deceleration. Cold starting and warm-up characteristics could be much improved. A significant advantage should be the improved fuel distribution over the whole speed load range. There is reason to believe that a lower octane requirement is probable at the same horsepower. Better volumetric efficiency can permit more horsepower from the engine.

Much interest has been displayed in the possible reduction of unburned hydrocarbons during deceleration of the vehicle. It appears feasible that fuels with less sensitive vapor pressures can be employed, thus improving hot running characteristics of the engine. Experiments indicate that a broader cut of fuel appears likely, probably with an end point in the range of 400 F.

The piston type power plant is founded on a basic cycle which permits the confinement of very high temperature gases within relatively low cost materials. This results in high cycle efficiency, good fuel economy, and durable life.

In considering engines designed for burning the more volatile fuels, with good part throttle economy, one is impressed by the recent advances in diesel combustion methods. These systems combine quiet operation, low fuel consumption, and a capacity to burn a broad range of fuels in cetane number and distillation range. The new MAN "Whisper" engine and the MWM balanced pressure combustion system permits burning distillate fuels as low as 15 cetane number and motor fuel of 83/90 octane.

Multifuel characteristics are receiving attention by military authorities in view of the possibility of a national emergency in which the diesel industry may be hard put to find sufficient diesel fuel of narrow specification limit to keep equipment operating.

Economy Fuels

On the other side of the ledger we see a consistent effort to burn economy fuels in conventional diesel engines. The railroads purchased diesel equipment on a 4 cents per gal diesel fuel basis; today it costs them about three times as much. In railroad diesel operations the cost of fuel represents 62 percent of the total operating expense, so every cent saved on present-day fuel means a reduction in operating

YEAR	KEROSENE	DISTILLATES			RESIDUALS		
		PREMIUM DIESEL	#2D FUEL	#2 FUEL	#4 FUEL	#5 FUEL	#6 FUEL
1953	9.81¢/GAL.	8.91	8.61	8.51	6.36	5.29	4.36
DIFFERENCE	0.90	0.31	0.10	2.15	1.07	.93	
1957	12.13	11.75	11.00	10.75	10.05	9.60	8.35
DIFFERENCE	0.38	0.75	0.25	0.70	0.45	1.25	

FIG. 4. Table of comparative costs at refinery of petroleum fuel 1953 and 1957.

cost by 6¼ percent, resulting in a substantial saving in a year's operation. The cost of fuel is closely dependent upon the balance of refinery economics and the ever-changing status of supply and demand.

Motor gasoline is the pertinent factor in influencing refinery economics and therefore has its effect on distillate and residual fuel characteristics as well as price. The present trend toward increasing quantities of the higher quality gasolines and distillate fuels leaves the residual stocks more undesirable for the appetite of the diesel engine unless accommodating means can be provided to accomplish their complete combustion.

In Fig. 4 the top line indicates the price per gallon at a midwest refinery of petroleum products for the year 1953 as compared with that of 1957. The differences in the cost reveal some significant changes. In 1953 there was a substantial drop between kerosine and premium diesel fuel and a more significant one between a No. 2 fuel oil and No. 4 residual fuel. This situation stimulated considerable activity to utilize residual fuels for diesel engines. In the year 1957, however, the difference is not clearly significant.

Advantages of burning residual fuels are at present less evident and point to the fact that the relative scarcity of residual fuels in some quarters and its rising demand is commanding better prices for residual fuels. Over and above the fuel cost considerations a balance must be achieved between low cost available fuels and low maintenance of operation.

What About Gas Turbines?

The gas turbine occupies a significant place when considering the burning of broad range fuels. The gas turbine in all of its varied applications permits operating on a wider range and variety of liquid hydrocarbons than normal piston engines. In automotive applications advantages are assured by the application of the turbine such as in (1) supercharged piston engines, utilizing in combination a turbine driven compressor in one or more stages, (2) the compound power plant particularly in the gasifier type of diesel, utilizing either the free piston type engine or other version of conventional diesel engines and of involving the use of a gas turbine as the final expansion stage, (3) the gas turbine itself in any one of its different forms as a source of power.

It is well established that the diesel fitted with an exhaust turbo-supercharger is the most economical type of thermal prime mover designed to achieve high efficiency. This development, however, has only been scratched. Advantages of turbocharging to the petroleum supplier are several. Supercharging has a tendency to reduce the ignition delay period which permits engines to run quieter and smoother; it becomes possible to burn fuels of lower cetane number and of lower volatility such as the heavy distillates or residuals.

Higher increases in supercharge boost are permissible if the high pressure stage is part of a compound system such as a gasifier as used in the Pescara free piston engine. Here the inherent efficiency of the cycle is high, the pressures and temperatures reach values not attainable in the case of normal diesel engines and heat losses are small due to the relatively less surfaces of the combustion chamber. The gas generator is well adapted to the combustion of heavy fuels.

The Free Piston Engine

In the development of free piston power plants as a contender for an eventual successor to the automotive piston engine some advantages are apparent from automotive sponsors. No weight advantage is at present evident, however, it has a superior torque curve and allows for split passage vehicle installation. There are other installation advantages in off-highway equipment which appear to be highly desirable in transmitting power to the point of utilization by pipelines rather than by transmission shafts. The free piston engine permits the use of less alloy content than required by gas turbines, has better economy than a regenerative gas turbine, particularly at part load, has good throttle response and as mentioned by Frey and Egli of Ford has important installation advantages.

Advances in Reciprocating Engines

Opportunities for engines of the

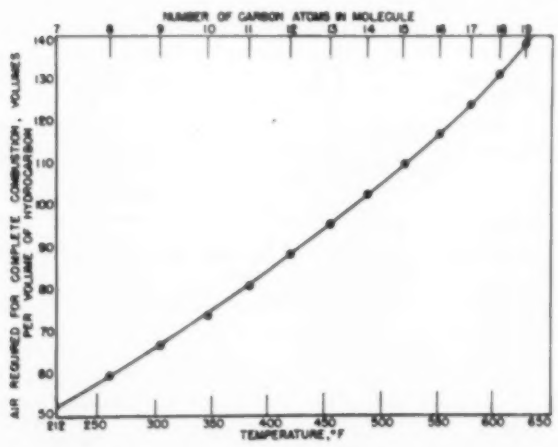
NUMBER OF CARBON ATOMS IN MOLECULE
AIR REQUIRED FOR COMPLETE COMBUSTION, VOLUMES PER VOLUME OF HYDROCARBON
TEMPERATURE, °F

FIG. 5. Relation of number of carbon atoms in molecule of fuel to air requirements for complete combustion.

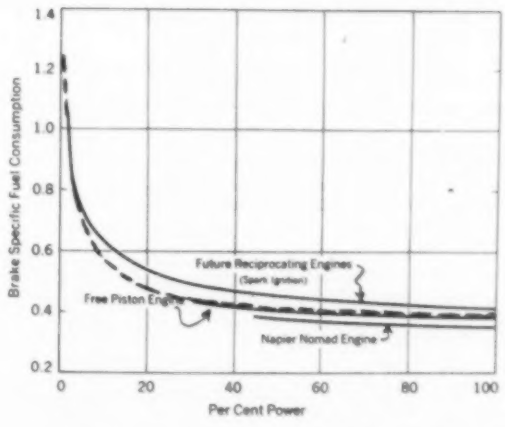

FIG. 6. Composite chart of future fuel consumption aims.

turbocharged and compound power plant type utilizing large quantities of excess air and high compression temperatures can be visualized by referring to Fig. 5. Here it can be seen that difficult fuels, high in the number of carbon atoms in the molecule require larger volumes of air per volume of hydrocarbon to achieve satisfactory combustion. It is also significant that the temperature levels necessary to initiate ignition of such fuels approach elevated values.

It is significant to note that without recent fundamental discoveries in reciprocating engines the gas turbine shows the greatest promise of any new type of power plant for potential development. In the future, gas turbine design, says Huebner of Chrysler: "A thermal efficiency of 40 percent in the next decade seems possible. This compares with a 28 percent which is about as good as we can do today with the automotive type piston engine."

In Fig. 6 data reported by Huebner compares the spark ignition engine with the free piston engine and the gas turbine. These predictions contemplate compressor efficiencies of 85 percent, regenerator effectiveness of 92 percent and gas temperatures of 2000 deg. From this it is stated: "Most thought-provoking is the realization that the automotive gas turbine, although still in its infancy, has its greatest development potentialities yet to come."

Development trends which have been exhibited by the application of the turbine for vehicles will be exploited to full advantage in off-highway installations. The advantages are:

1. The reduction of weight and bulk,
2. the use of available low cost fuels,
3. operation in any climate,
4. low maintenance, and
5. simplified transmissions.

Concerning gas turbine fuels, the acceptable wide boiling range permits the utilization of fuels which require less processing of a barrel of crude and therefore permits greater yield in products suitable for gas turbines.

Lubrication Problems

The lubricants necessary for proper lubrication of higher speed bearings is more difficult than usually found in automotive type piston engines. The severest conditions imposed upon a gas turbine lubricant is that of repeated accelerations and decelerations which impose high "soak-back" temperatures into the shaft and bearings. These are further accentuated by quick stalls of the gas turbine. Much work is yet needed to be done on bearing lubrication.

The lubrication of free piston engines is still in a state of flux. Should the approach be the utilization of higher detergent oils or of improved techniques in the processing of straight mineral oil? The type of lubricant which can yield low wear at high pressure ratios between piston rings and cylinders and yet not leave tell-tale deposits is much needed.

A new phase of lubrication research is evident because of the necessity for determining factors which are vaguely spoken of as film strength and lubricity. This pertains to all types of modern power plant developments including the piston engine and calls for a new phase of research activity to uncover procedures which will determine suitable lubricants against breakdown from high Hertz stresses. Today we are faced with a problem, associated with cams, tappets, pistons, and rings which open avenues to discover new techniques in lubricants and test procedures.

We can picture ourselves as standing at the crossroads and taking inventory of the highly developed and eminently successful piston engine on the one hand and on the other attempting to project an evaluation of the future application of the turbine in all its ramifications. ★ ★ ★

U. S. Could Nearly Double LPG Production In Emergency

A recent report made to the National Petroleum Council shows that, in the event of national emergency, domestic production of liquefied petroleum gases could be almost doubled on an "expanded plant" basis. This report presumes, of course, that proration of crude oil and natural gas production would be lifted in an emergency along with construction of facilities to recover as much LPG as possible from the available gas supply.

The report was prepared by a NPC Committee headed by W. K. Warren, chairman of the board and chief executive of Warren Petroleum Corporation, and at the request of H. A. Stewart, director of the Office of Oil and Gas, United States Department of the Interior.

Two conditions were assumed:

1. Maximum availability through present facilities, and
2. Maximum availability through facilities expanded to recover as much as possible from the available gas supply.

Here's what the committee found out, among other things:

1. That productive capacity for LPG is expected to increase by 816.6-million gal in 1957. This is not, the report cautions, a reliable measure of the actual production (8482-million gal in of increased production potential.
2. Total LPG production could be much greater than present production (8482-million gal in 1956) in present plant facilities — up 51 percent to 12,819.5-million gal. Under expanded plant conditions, production could be 15,383.0-million gal, up 81 percent from actual production in 1956.
3. Greatest potential increase in the event of emergency would be in the Texas Inland, Texas Gulf Coast and Oklahoma-Kansas-Missouri refining districts.
4. Under normal conditions the larger increase in LPG availability would be at refineries; under an emergency the larger increase would be at natural gas liquids plants.

As the tabular data show, more than 60 percent of the anticipated increase in production capacity in 1957 will come from refineries.

Probable Availability of LPG in 1957 and Under Emergency Conditions.* (Thousands of Gallons)

	Actual 1956 Production Bureau of Mines	Anticipated Plant Capacity Increase-1957	Emergency LP-Gas Availability (1) Present Plant	Emergency LP-Gas Availability (2) Expanded Plant
		By Products		
Propane	4,096,372	517,954	6,053,409	7,861,547
Butane	2,043,675	234,642	3,036,404	3,992,842
Iso butane	410,821	40,001	582,682	866,597
B-P mix	847,148	-76,839	636,004	633,955
Other mix	1,084,043	100,861	1,881,043	2,028,062
Total U. S.	8,482,059	816,619	12,189,542	15,383,003
		By Type of Plant		
Natural gas liquids plant	6,299,655	321,085	8,444,546	11,180,779
Refinery	2,182,404	495,534	3,744,996	4,202,224
Total U. S.	8,482,059	816,619	12,189,542	15,383,003

*National Petroleum Council Survey, Released October 3, 1957.

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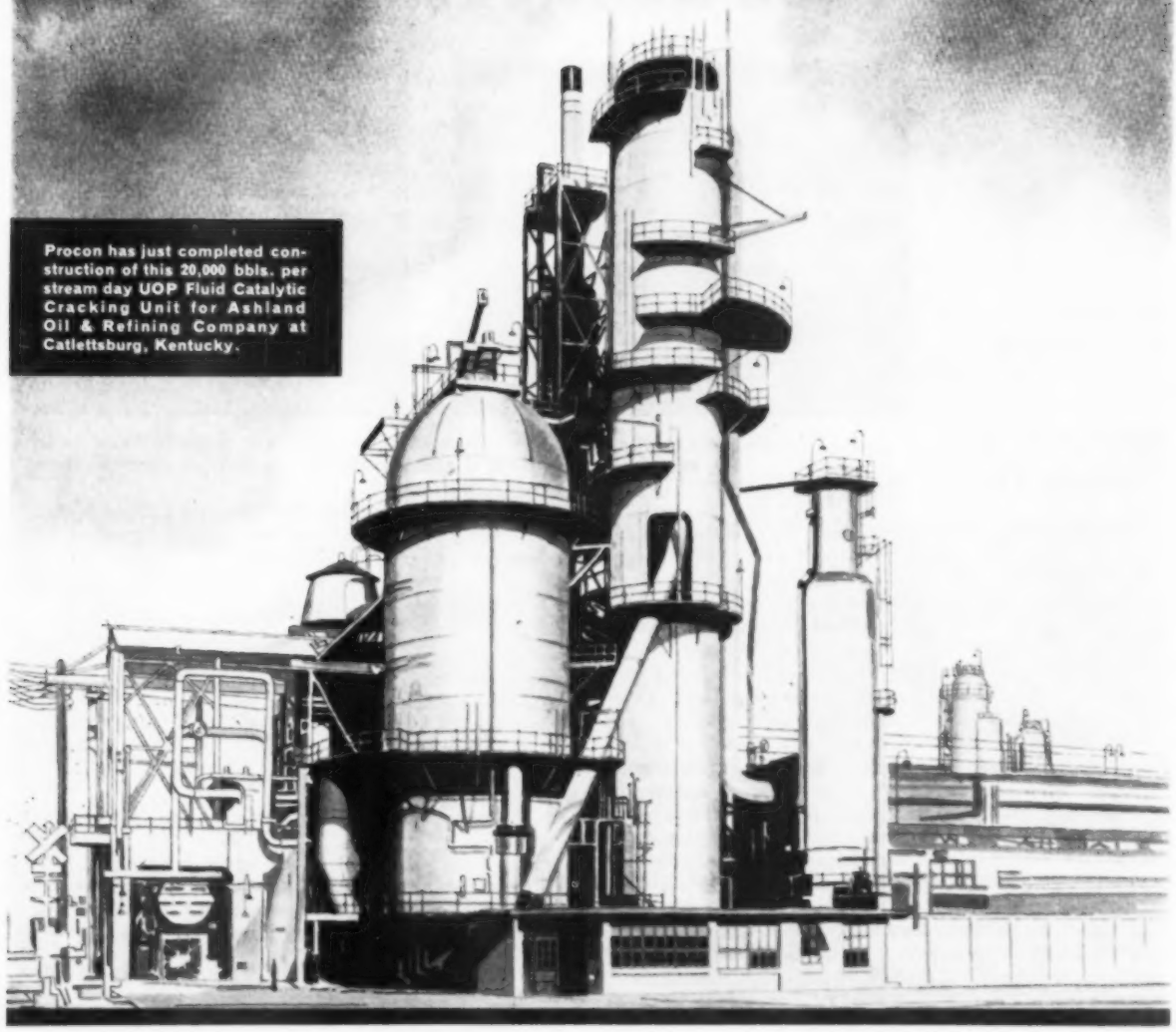

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DESIGN HANDBOOK

How to Design Finned Tube Shell and Tube Heat Exchangers

	PART	
Fundamentals of Finned Tube Heat Transfer	1	• *Basic heat transfer relationships; example problems*
Design of Finned Tube Condensers	2	• *Selection and sizing of equipment for hydrocarbons and other organic compounds*
Design of Finned Tube Heaters and Coolers	3	• *Design relationships; liquid-liquid cooler sample problems; economics of finned tube exchangers*
Design of Finned Tube Partial Condensers	4	• *Rigorous and approximate methods; how to design for saturated and superheated feeds*

Edwin H. Young
Dennis J. Ward

FINNED tubes can usually be used to advantage in shell and tube condensing applications where the fin side condensing coefficient is lower than the tube side coefficient. Such a situation normally exists in most organic condensers. This is illustrated by the universal use of finned tubes for condensing refrigerants in the refrigeration industry. How to determine if finned tubes can be used to advantage in petroleum and petrochemical applications is the subject of this second article in a series of finned tube heat transfer.[1]

An understanding of how finned tubes perform in condensing applications is necessary in order to determine whether finned tubes should be specified. A number of papers have been published reporting the performance of finned tubes in condensing applications.[2-8] Nusselt[9] has presented theoretical relationships for condensing of saturated vapors on horizontal and vertical surfaces. These relationships may be applied to the horizontal tube portion (root section) and vertical fin section of a finned tube for predicting the mean coefficient on a horizontal finned tube. Nusselt's relationship for a single horizontal bare tube is:

$$h_r = 0.725 \left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f D \Delta t_{cf}} \right]^{1/4} \quad . \quad . \quad . \quad . \quad (1)$$

Nusselt's relationship for condensing on a vertical surface is:

$$h_f = 0.943 \left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f L \Delta t_{cf}} \right]^{1/4} \quad . \quad . \quad . \quad . \quad (2)$$

Equations 1 and 2 were derived by Nusselt by taking into consideration the forces acting on the condensate film, using the assumption that the flow of the condensate is laminar.

Beatty[10] developed a relationship involving an equivalent diameter for finned tubes which incorporates Equation 1 for the horizontal portion (root section) of the finned tube and Equation 2 for the vertical finned portion of the tube. The equivalent diameter for condensation is obtained in the following manner:

Let

$$q_{total} = h'_o A_{eq} \Delta t_{cf} = h_r A_r \Delta t_{cf} + h_f A_f \phi \Delta t_{cf} \quad . \quad . \quad . \quad . \quad (3)$$

Where the subscripts r and f refer to the root and finned portion of the tube respectively and A_{eq} is given by Equation 13 of Reference 1.

Substitution of Equation 1 and Equation 2 into Equation 3 and solving for h'_o assuming that Δt_{cf} in Equation 1 is the same as Δt_{cf} in Equation 2 gives:

$$h_o' = 0.725 \left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f \Delta t_{cf}} \right]^{1/4} \left(\frac{A_r}{A_{eq} D_r^{1/4}} + \frac{1.30 \phi A_f}{A_{eq} L^{1/4}} \right) \quad . \quad . \quad . \quad . \quad (4)$$

A comparison of Equation 4 with Equation 1 indicates that the equivalent diameter of a finned tube is:

$$\left(\frac{1}{D_{eq}'} \right)^{1/4} = \frac{A_r}{A_{eq} D_r^{1/4}} + 1.30 \frac{\phi A_f}{A_{eq} L^{1/4}} \quad . \quad . \quad (5)$$

where

$$L = \frac{\text{area of one side of one fin}}{\text{diameter of fin}} \quad . \quad . \quad . \quad (6)$$

Therefore the temperature difference form of Beatty's equation for a single finned tube may be written as:

$$h_o' = 0.725 \left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f \Delta t_{cf} D_{eq}'} \right]^{1/4} \quad . \quad . \quad . \quad . \quad (7)$$

ϕ = fin efficiency[1]

In deriving Equation 7 Beatty assumed that the temperature drop across the condensate film on the fin was the same as the temperature drop across the condensate film on the root portion of the tube. A more precise relationship can be derived without making this assumption by allowing for the effect of the fin efficiency on the Δt_{cf} over the fin portion of the tube. The resulting relationship for a single tube is:

$$h_o' = 0.725 \left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f \Delta t_{cf}} \right]^{1/4} \left(\frac{A_r}{A_{eq} D_r^{1/4}} + \frac{1.30 \phi^{3/4} A_f}{A_{eq} L^{1/4}} \right) \quad . \quad . \quad . \quad . \quad (8)$$

where

Δt_{cf} = the temperature drop across the condensate film in the root portion of the tube.

A comparison of Equation 8 with Equation 4 indicates that the fin efficiency ϕ appears in Equation 8 to the $^3/_4$ power and in Equation 4 to the first power. The Δt_{cf} of Equation 4 is given by:

$$\Delta t_{cf} = \left(\frac{U_o}{h_o'}\right)(\Delta t)_m \quad . \quad . \quad . \quad . \quad . \quad (9)$$

whereas the Δt_{cf} of Equation 8 is given by:

$$\Delta t_{cf} = \left(\frac{U_r}{h_r}\right)(\Delta t)_m \quad . \quad . \quad . \quad . \quad (10)$$

where

U_r = the overall coefficient for the root portion of the finned tube,

h_r = given by Equation 1.

In normal organic condensing applications involving low finned tubes the fin efficiency is close to 100 percent and the use of Equation 8 is not warranted. If low conductivity metal finned tubes are used with relatively high condensing coefficients the use of Equation 8 is recommended since it is more exact and gives slightly higher condensing coefficients. For a fin efficiency of 100 percent Equation 4 and Equation 8 give identical results. The use of Equation 4 is illustrated in the design of a condenser.

An alternative design procedure is to replace the temperature difference, Δt_{cf}, by a tube loading term, W_1. The necessary relationship is derived in the following manner. Raising both sides of Equation 7 to the fourth power:

$$(h_o')^4 = (0.725)^4\left(\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f \Delta t_{cf} D_{e'q}}\right) \quad . \quad . \quad (11)$$

but by Equation 3

$$q = h_o' A_{eq} \Delta t_{cf}$$

and

$$q = w_1 \lambda L' \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

where

w_1 = pounds per hour per foot of tube length.

L' = length of tubing (feet),

λ = latent heat of vaporization, btu per lb.

Substituting Equation 12 into Equation 3 and then substituting the result into Equation 11 and simplifying gives:

$$h_o' = 0.65\left(\frac{k_f^3 \rho_f^2 g_c A_{eq}}{\mu_f D_{e'q} w_1 L'}\right)^{1/2} \quad . \quad . \quad . \quad (13)$$

which is the tube loading form of Beatty's equation for finned tubes.

Relationships 7, 8, and 13 are for single tubes. As indicated earlier these relationships assume laminar flow of the condensate film. The theoretical correction factor for the influence of the number of tubes in a vertical row is given by Nusselt as $\left(\frac{1}{N}\right)^{1/4}$ for equation 7 and 8 and $\left(\frac{1}{N}\right)^{1/2}$ for Equation 13 where N is the average number of tubes in a vertical row. The work of Katz,[5,7] Geist,[5] Short and Brown,[11] and Young and Wohlenberg[12] indicates that the correction factor of Nusselt is too severe and that a turbulence correction factor probably should be included in Nusselt's equations when applied to multitube units. The correction for

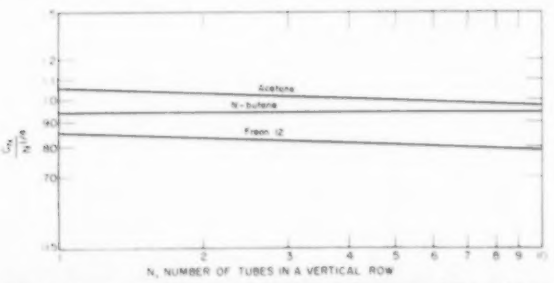

FIG. 1. Plot for condensation of acetone, N-butane and Freon 12 on six finned tubes in a vertical row.

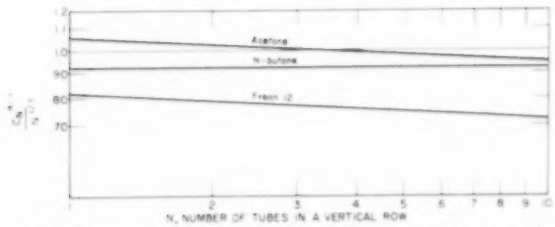

FIG. 2. The same data as shown in Fig. 1, for use in the tube loading method.

turbulence C_n as given by Katz, Young, and Balekjian[7] can be included in Equation 7 and Equation 13 as follows:

$$h_o' = 0.725\left(\frac{C_n}{N^{1/4}}\right)\left[\frac{k_f^3 \rho_f^2 g_c \lambda}{\mu_f \Delta t_{cf} D_{e'q}}\right]^{1/4} \quad . \quad . \quad (7a)$$

$$h_o' = 0.65\left(\frac{C_n^{4/3}}{N^{1/3}}\right)\left[\frac{k_f^3 \rho_f^2 g_c A_{eq}}{\mu_f D_{e'q} w_1 L}\right]^{1/2} \quad . \quad . \quad (13a)$$

Fig. 1 presents a plot of $\left(\frac{C_n}{N^{1/4}}\right)$ for condensation of Acetone, N-Butane and Freon 12, on six finned tubes in a vertical row from the data of Katz and Geist.[5] Fig. 2 presents $\left(\frac{C_n^{4/3}}{N^{1/3}}\right)$ from the same data for use in the tube loading method. Examination of these figures indicates that the Nusselt correction factor $\left(\frac{1}{N}\right)^{1/4}$ is counterbalanced by a C_n value which for all practicable purposes results in a correction factor virtually independent of the number of tubes in a vertical row. This conclusion based on the data of Katz and Geist substantiates the findings of Short and Brown.[11] A C_n plot based on the data of Young and Wohlenberg[12] for five bare tubes in a vertical row is compared with the C_n curve for Freon 12 condensing on six finned tubes in a vertical row in Fig. 3. This figure indicates that the C_n correction for bare tubes is the same as for finned tubes. The data of Young and Wohlenberg[12] supports the conclusion that the correction $\left(\frac{C_n}{N^{1/4}}\right)$ for plain tubes is also virtually independent of the number of tubes in a vertical row. It is recommended that an average value of $\left(\frac{C_n}{N^{1/4}}\right)$ be used in Equation 7a for tube bundles having an average number of tubes in a vertical row less than 10. The recommended values are tabulated in Table 1 for three condensing vapors.

TABLE 1. Average Values:

Fluid	$\left(\frac{C_n}{N^{1/4}}\right)$	$\left(\frac{C_n^{4/3}}{N^{1/3}}\right)$
Acetone	0.97	0.96
N-Butane	0.94	.92
Freon-12	0.80	.74

For bundles having more than 10 tubes (average) in a vertical row, it is recommended that the lines in Fig. 1 and

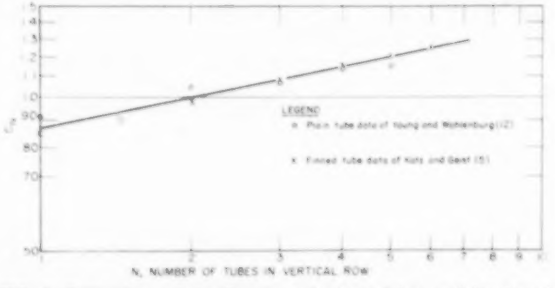

FIG. 3. Comparison of the C_n curves for bare tubes and for finned tubes. (See text.)

2 be extrapolated. The average number of tubes in a vertical row for condensers having more than twenty tubes and single pass arrangements on the shell side can be estimated by the use of Equation 14 and 15:

$$N = 0.815(X)^{.52} \text{ for square pitch arrangement} \quad (14)$$

$$N = 0.40\ (X)^{0.54} \text{ for triangular pitch arrangement} \quad (15)$$

where

X = total number of tubes.

ECONOMIC CONSIDERATIONS

Industrial bare tube heat exchanger cost curves can be used for estimating finned tube heat exchanger costs by subtracting the cost of the bare tubing and adding the cost of the finned tubing. For example the current cost of a ¾ in. — 19 fin per in. admiralty tube (.065 in. root wall) costs 20 percent more per pound or 40 percent more per foot than a ¾ in. — 16 gage bare tube. Donohue,[13] Zimmerman and Lavine,[14] and Kern[15] have presented recent cost data on heat exchangers.

EXAMPLE DESIGN OF A DEBUTANIZER OVERHEAD CONDENSER

Comparable designs of bare tube and finned tube condensers to condense 150,000 lb per hour of a 20-80 mole percent mixture of C_3 and N-C_4 at 160 psia are desired. Treated cooling tower water is available at 80 F and is not to exceed an outlet temperature of 120 F. Three-fourths inch OD admiralty tubes are to be used in the designs.

TABLE 2. Tube Specifications.

Description	Bare Tube ¾" — 18 BWG Admiralty	Finned Tube 19 ft/inch — ¾" O.D. — 18 BWG Admiralty
O.D. inches	0.750	0.737
I.D. inches	0.652	0.541
D_{root} inches		0.641
X = Wall thickness, inches	0.049	0.050
A_o, sq ft/ft	0.1963	0.438
$\frac{A_o}{A_i}$	1.15	3.18
A_{es}, ft²/tube	0.00232	0.001605

A. Preliminary Calculations.

1. From the equilibrium values for these compounds[16] the dew point and bubble point of the mixture were computed as:

   Dew point = 166 F

   Bubble point = 154 F

2. Assuming a linear temperature drop of the condensate with Q and the maximum temperature rise of the water, the mean temperature difference is:

$$\Delta t_{lm} = \frac{(154\text{-}80) - (166\text{-}120)}{\ln \frac{74}{46}} = 58.8 \text{ F}$$

3. The change in enthalpy of the pure components is:[17]

$\Delta H_{c_3} = 126$ Btu/lb.

$Q_{c_3} = 126$ Btu/lb × 24,750 lb/hr = 3,120,000 Btu/hr.

$\Delta H_{c_4} = 137$ Btu/lb.

$Q_{c_4} = 137$ Btu/lb × 125,250 lb/hr = 17,180,000 Btu/hr for a total heat duty of

$Q = Q_{c_4} + Q_{c_3} = 3.12 \times 10^6 + 17.18 \times 10^6 = 20.3 \times 10^6$ Btu/hr.

4. The water flow rate is:

$$W = \frac{20{,}300{,}000}{40} = 507{,}500 \text{ lb/hr}$$

or (assuming $\rho = 62$ lb/ft³)

2.27 cu ft/sec

B. Design of Finned Tube Condenser.

Assume a 27 in. ID shell containing 65 tubes ten feet long on a 15/16 in. triangular pitch each with two passes on the tube side.

1. Water flow rate and film resistance

$$A_{flow} = \frac{656}{2} \times 0.001605 = 0.526 \text{ ft}^2$$

$$V_t = \frac{2.27}{0.526} = 4.31 \text{ ft/sec}$$

$$V_t^{0.8} = (4.31)^{0.8} = 3.23$$

for water[19]

$$h_i = \frac{150\ (1 + 0.011 t_\omega)\ v_t^{0.8}}{d^{0.2}} = \frac{150\ (2.1)\ (3.23)}{(0.541)^{0.2}}$$

$$= 1150 \text{ Btu/hr} - \text{F} - \text{sq ft}$$

$$\frac{A_o}{A_i h_i} = \frac{3.18}{1150} = 0.00276$$

2. Metal Resistances.

The fin resistance from Fig. 5 of the first article[1] is:

$$r_f = 0.00011$$

The root metal resistance is:

$$r_m = \frac{X A_o}{K A_m} = \frac{(0.050)\ (0.438)}{(12)\ (65)\ (0.152)} = 0.00019$$

3. Fouling Resistances.

The outside and inside fouling resistance (from TEMA[18]) are:

$r_o' = 0.0005$ $r_i = 0.001$

The fouling resistance on the inside of the tube is:

$$\frac{A_o}{A_i} r_i = 3.18 \times 0.001 = 0.00318$$

4. Condensing Coefficient.

The condensing coefficient is computed from equation (7a):

$$h_o' = 0.725 \left(\frac{C_n}{N^{1/4}}\right)\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4} \left(\frac{1}{D_{e'_o}}\right)^{1/4} \left(\frac{1}{\Delta t_c}\right)^{1/4} (\lambda)^{1/4}$$

The Nusselt condensing physical property group. $\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4}$ for the condensing mixture is given in Table 3. The $\left(\frac{C_n}{N^{1/4}}\right)$ value obtained from Table 1 or Fig. 1 for the condensing butane is 0.94. The equivalent condensing diameter, defined by Equation 5 is calculated for various outside resistances. The computed values for the finned tube given in Table 2 are tabulated below (see Table 4).

TABLE 3. Nusselt Physical Property Group of Propane — Butane Mixture.

Temperature F	$\left[\frac{k_f^3 \rho_f^2 g_c}{\mu_f}\right]^{1/4}$
100	170
120	171
140	171.5
160	172

TABLE 4. Equivalent Diameter of Tube.

$\left[\frac{1}{\frac{1}{h_o'} + r_o'}\right]$	$\left(\frac{1}{D_{e'_o}}\right)^{1/4}$
0	3.53
400	3.52
800	3.49
1200	3.48
Average Value	3.50

DU PONT *Petroleum Chemicals* NEWS

Number 81 in a Series of Bulletins for the Petroleum Industry

NOVEMBER 1957

New anti-icing additive offers economic advantage to refiners

YOU OUGHT TO KNOW...

JOSEPH G. EVANS is manager of the Petroleum Chemicals Division's San Francisco district, which includes the important northern California refining area near Du Pont's tetraethyl lead plant at Antioch.

Mr. Evans joined the Du Pont Company in December, 1951. He was at first assigned to sales service in the Mid-Continent region with headquarters in Tulsa.

Prior to this he was development engineer for a stoker company in western Pennsylvania, and later organized a company distributing industrial chemicals and specialized lubricants.

Mr. Evans is a graduate of Texas A & M. During the second world war he was an officer in the U.S. Navy, on submarine duty in the Pacific. He was recalled to active duty in 1950 and served two years on a destroyer off Korea. He is a member of the Society of Automotive Engineers, National Sales Executives and the Board of Directors of the San Francisco Sales Executives' Association.

Engine stalls caused by carburetor icing have become more annoying to motorists in recent years. This is because automatic chokes and transmissions on newer cars make it difficult to prevent stalls by "gunning" the engine, especially in heavy traffic. Power brakes and steering, less effective when the engine stops, make stalls a still greater problem.

THIS DEMONSTRATION DEVICE clearly shows the causes and prevention of carburetor icing. It consists of a small ice-cooled air intake and a 1.6-horsepower engine connected to it by a transparent manifold. When unprotected gasoline is drawn through the tube, ice visibly forms and causes the engine to stall. But the addition of DMF to the gasoline maintains constant, ice-free carburetion.

More and more refiners are now using additives in gasoline to prevent carburetor icing. One of the most effective is Du Pont DMF (dimethyl formamide) antistall additive. It is economical; only a little is required for protection. In many instances, less than two milliliters of DMF per gallon of gasoline are needed to keep carburetors ice-free. Therefore DMF is economical to ship, to store and to add to gasoline.

(Continued)

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OVER

DU PONT *Petroleum Chemicals* NEWS

CONTINUED *Anti-icing additive*

Marketing advantages

Since motorists are becoming increasingly aware of carburetor icing and the stalling annoyance it causes, you can profitably feature your use of DMF in advertising and promotion campaigns.

To help you capitalize on the motorist benefit of DMF, we have prepared a number of sample ads, poster designs and sales aids (shown above). These dramatize the anti-stalling advantage of gasolines containing DMF. The ideas can be incorporated in your advertising.

Just drop us a line or get in touch with any Petroleum Chemicals Division representative.

In 1956 Du Pont spent $48,000,000 in Texas

During 1956, more than 2,000 Texas firms sold over $30,200,000 worth of goods and services to Du Pont plants in Texas. During the same year, Du Pont payrolls in Texas amounted to more than $17,700,000.

The purchases included raw materials used in chemical manufacturing . . . natural gas, butadiene, propane, ammonia, chlorine, caustic, ethylene, cyclohexane, lubricating oils, and nitric, acetic and sulfuric acids.

Small business concerns supplied many of the more unusual items and services, such as embroidery hoops and cotton gun patches used in analytical work. And a group of Texas oil well drilling experts was retained by the Victoria plant to perforate the steel casing in a 5,000-foot brine disposal well.

Watch the Du Pont "Show of the Month," CBS Network

Importance of credit cards pointed up by findings of new Du Pont survey

What do people really think about oil company credit cards? Finding the answer to that question was one of the objectives of a new study of service station customers' motivations recently completed by National Analysts, Inc., Philadelphia, for the Du Pont Petroleum Chemicals Division.

The survey revealed that 58% of the 2,036 motorists interviewed were favorably disposed toward the credit card principle. Only 16% were opposed, while 26% were undecided. Apparently *this* group is ripe for credit card promotion. An earlier Du Pont survey showed that credit card customers are more loyal to one brand of gasoline than those who do not buy on credit.

Here's why . . .

The new Du Pont survey probed also into the reasons why customers are predisposed toward credit cards. Card holders gave varying reasons for using them: for example, that they were convenient to have on trips and that they enabled motorists to buy gasoline when short of cash. A few card holders retained oil company invoices as records of gasoline and oil purchased.

In spite of the fact that the majority of service station customers' attitudes toward credit cards were favorable, only 18% of all motorists had cards. Of these, 13% had one and 5% had cards from more than one company.

Motivations vary by region

The national survey report has been analyzed to determine regional differences of habit and opinion.

These of course will prove of interest to all oil company marketing men, but especially to those with only regional distribution.

Credit cards are more widely accepted and used in the west coast and southern states.

Such information is but a small part of this new survey. The complete findings have been published in the new book, "Buying Patterns at Service Stations," now being distributed to oil company marketing executives. Requests from others in the industry will be welcomed and filled promptly.

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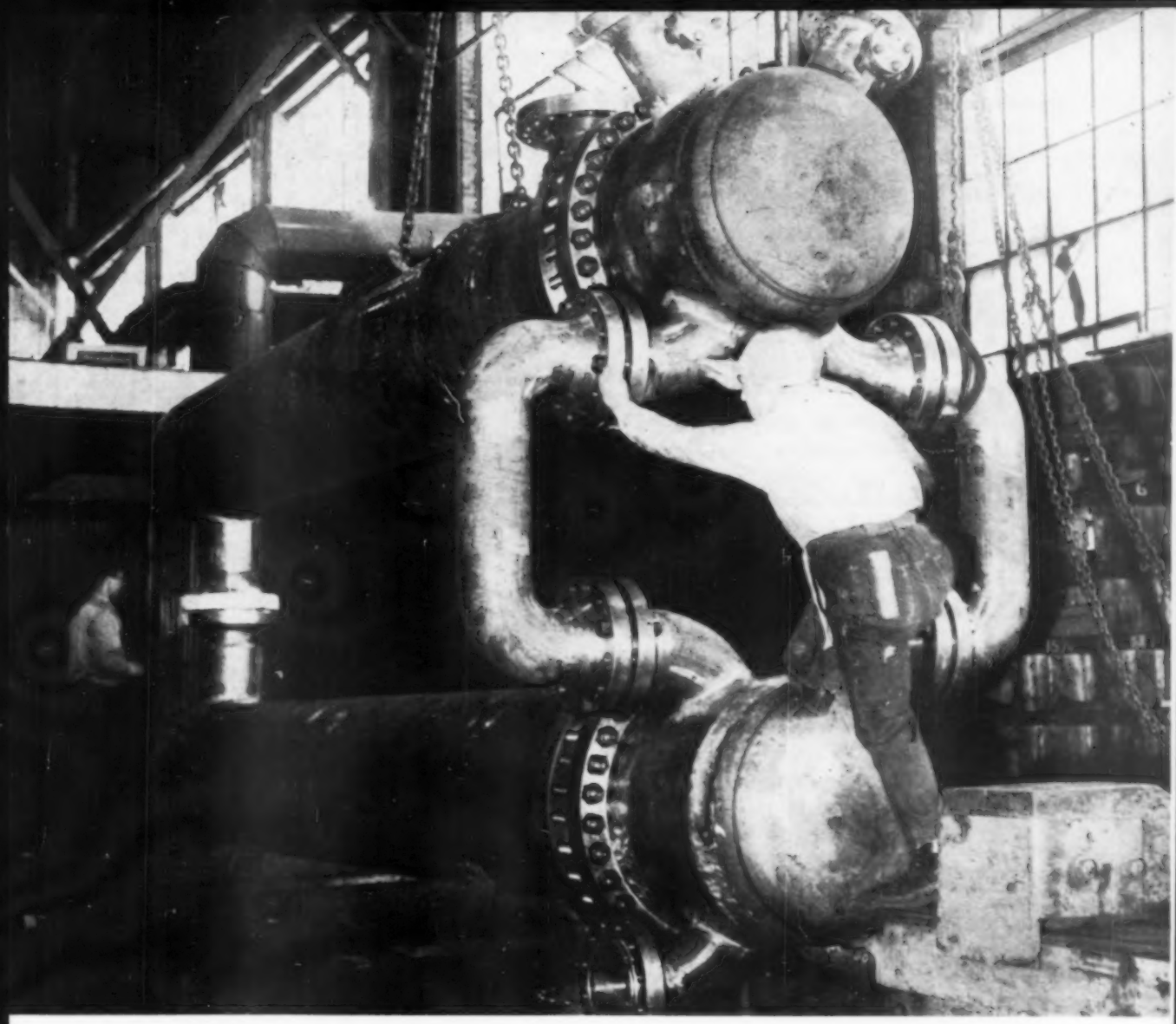

"Special" in Every Way

Made entirely from Type 321 stainless steel, this unusual heat exchanger demonstrates The M. W. Kellogg Company's ability to engineer and fabricate such equipment to special as well as standard specifications. In this case, special welding procedures were developed, as well as special methods of seal-welding tubes to tube sheets; special machining of the tube sheet was required for each tube; and special techniques were employed for testing. Special in every way, this unit is scheduled for special service in an English oil refinery.

FABRICATED PRODUCTS DIVISION

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Nomenclature

h_r = heat transfer coefficient on finned section of tube, Btu/hr-°F-sq ft.
h_f = heat transfer coefficient on root section of tube, Btu/hr-°F-sq ft.
k_f = thermal conductivity of condensed liquid evaluated at average film temperature, Btu/hr-°F-ft.
ρ_f = density of condensed liquid evaluated at average film temperature, lb/ft.^{3}
g_c = gravitation constant, 4.17×10^8 ft/hr.^{2}
λ = latent heat of vaporization, Btu/lb.
μ_f = viscosity of condensed liquid evaluated at average film temperature, lb/ft-hr.
D = outside diameter of bare tube, ft.
Δt_{cf} = temperature drop across condensate film, °F.
L = height of vertical surface, ft.
t_f = mean condensate film temperature, °F, $t_f = t_{sv} - \frac{1}{2}\Delta t_{cf}$.
t_{sv} = saturation temperature of condensing vapor, °F.
h_o' = actual finside heat transfer coefficient, Btu/hr-°F-sq ft.
A_{eq} = equivalent outside heat transfer area (see Equation 13 of Reference 1), sq ft.
A_r = outside finned tube root area, sq ft/ft.
A_f = outside finned tube fin area, sq ft/ft.
ϕ = fin efficiency (see Reference 1).
$D_e'_q$ = equivalent condensing diameter for a finned tube, ft (see Equation 5).
D_r = root diameter of a finned tube, ft.
U_o = overall heat transfer coefficient, Btu/hr-°F-sq ft (outside surface).
$(\Delta t)_m$ = mean overall temperature difference, °F.
q = rate of heat transfer, Btu/hr.

Examination of Table 4 indicates that the equivalent condensing diameter of this tube is essentially constant with an average value of 3.50. Substituting in Equation 7a:

$$h_o' = 0.725\ (0.94)\ (3.50)\ (3.4)\ (171.5) \left(\frac{1}{\Delta t_f}\right)^{1/4}$$

$$h_o' = 1390 \times \left(\frac{1}{\Delta t_c}\right)^{1/4}$$

The condensing coefficient is first assumed to be:

$$h_o' = 600$$

Rewriting Equation 20 of part 1[1]:

$$\frac{1}{U_o} - \frac{1}{h_o} = r_o' + r_f + r_w \frac{A_o}{A_m} + r_i \frac{A_o}{A_i} + \frac{1}{h_i}\frac{A_o}{A_i}$$

Substituting:

$$\frac{1}{U_o} - \frac{1}{h_o'} = 0.00011 + 0.0005 + 0.00019 + 0.00318 + 0.00276 = 0.00674$$

Substituting for $h_o' = 600$:

$$\frac{1}{U_o} = \frac{1}{600} + 0.00674 = 0.00841$$

$$U_o = 119.0$$

The temperature drop across the condensate film by Equation 9 is:

$$\Delta t_c = \frac{U_o}{h_o'}(\Delta t_m) = \frac{119}{600}\ (58.8) = 11.65\ \text{F}$$

Checking the assumed h_o' of 600:

$$h_o' = 1390 \times \left(\frac{1}{11.65}\right)^{1/4} = 756$$

which does not check.

Second Trial

Assume $h_o' = 800$, then

$$\frac{1}{U_o} = \frac{1}{800} + 0.00674 = 125$$

$$\Delta t_c = \frac{125}{800} \times 58.8 = 9.19\ \text{F}$$

$$\text{or } h_o' = 1390 \left(\frac{1}{9.19}\right)^{1/4} = 800$$

which checks exactly the assumed value of 800.

Therefore

$$U_o = 125 \text{ and } \triangle t_m = 58.8\ \text{F}$$

The required area is

$$A = \frac{Q}{U\Delta t_m} = \frac{20{,}300{,}000}{(125)(58.8)} = 2760 \text{ sq ft (external)}$$

The provided area is

$$A = 656 \times 10 \times 0.438 = 2870 \text{ sq ft external}$$

for an excess of

$$\%\ \text{XS} = \frac{110}{2760} = 4\%$$

A plain tube condenser, designed using the same procedure, required a 35 in. shell containing 988 tubes ten feet long with six passes on the tube side. A summary and comparison of the plain and finned units are given in Table 5.

TABLE 5. Summary of Requirements.

Item	Plain Tube	Finned Tube
Heat duty, Btu/hr	20,300,000	20,300,000
Δt_m, F	58.8	58.8
Twater in, F	80	80
Twater out, F	120	120
Water velocity, ft/sec	5.94	4.31
Outside fouling factor	.0005	.0005
Inside fouling factor	.001	.001
U_o, Btu/hr-F-sq ft (outside)	183	125
U_t, Btu/hr-F-sq ft length	35.9	54.7
Shell diameter, inches	35	27
No. of tubes	988	656
Tube length, ft	10	10
No. tube passes	6	2
Required area, sq ft	1890	2760
Area provided, sq ft	1941	2870
% XS area	2.7	4.0
Exchanger cost	$12,000	$10,400
Savings, dollars	—	1600
Savings, %	—	13.3

ACKNOWLEDGMENT

Permission by Wolverine Tube Division of Calumet and Hecla, Inc. to publish this paper is appreciated.

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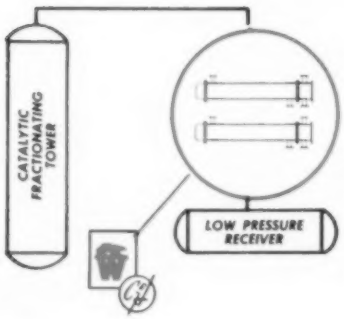

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Because of Wolverine Trufin Type S/T condenser tube, new standards of efficiency and economy are daily being established in the field of heat transfer. Diagramed above is another Trufin installation—this time the condensing, for a large Midwest refinery, of hydrocarbon overhead vapors from a catalytic cracking unit fractionating tower.

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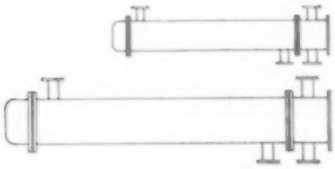
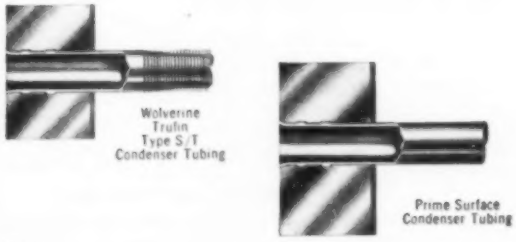
1

INCREASED EFFICIENCY—Trufin Type S/T is an extended surface tube with its fins an integral part of the tube wall. Because of this, Type S/T has more than two times the heat transfer surface of prime surface tube—extracts more BTU's per foot of tube. Shown here are comparable lengths of tube for equivalent heat transfer surfaces.



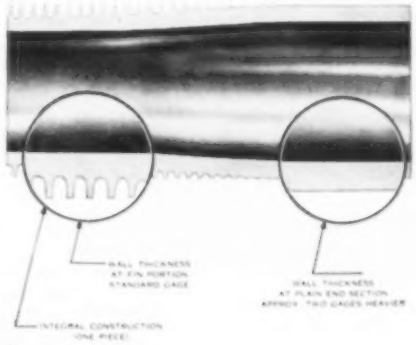
2

LOWER COST—Type S/T's additional outside surface area permits the use of less tube for a given heat duty. You get smaller shells, baffles, reduce fabricating costs with lower maintenance because there are less tubes to clean.



3

EASY INSTALLATION—Trufin Type S/T rolls into headers as easily as plain tube—uses the same fabrication methods. Standard rolling-in tools are used. There is no deviation from existing fabrication procedures.



4

ENGINEERED FOR THE JOB—Trufin Type S/T is specifically designed for shell and tube applications. The cutaway photograph illustrates its unique, one-piece construction. Because of this, Type S/T gives constant efficiency—its fins are unaffected by thermal shock, vibration or varying pressures.

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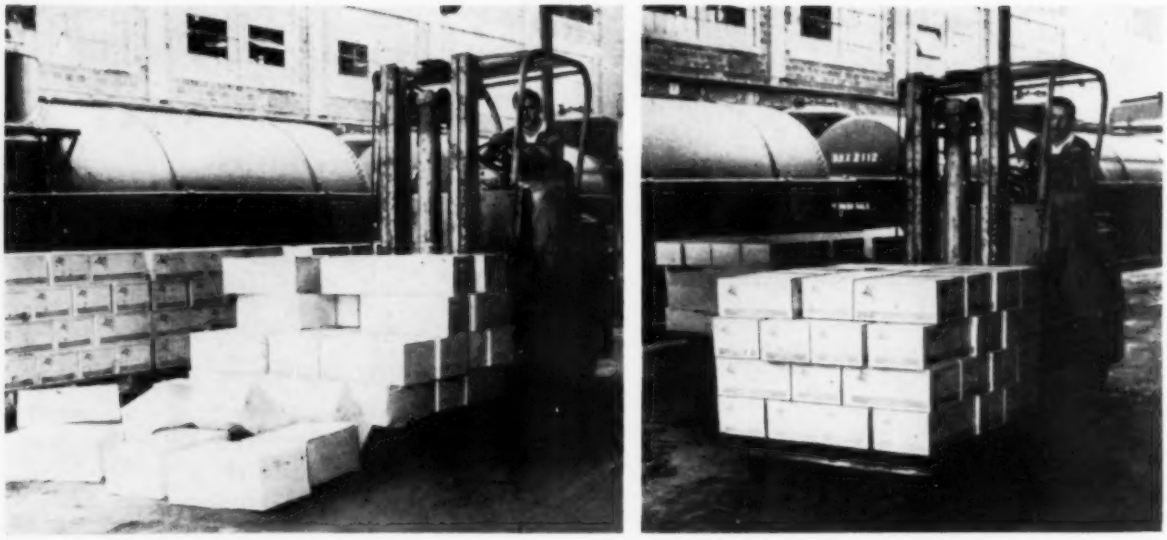


FIG. 1. Results of a sudden-stop test with filled, treated and untreated containers; A, untreated boxes of wax, and B, treated.

How to 'BIND' Package Loads Together, at low cost

New Box surface coating prevents slip when handling and transporting containers.

Earl L. Kullman
Socony Mobil Oil Company, Inc.

Cooperative development by three companies* has perfected a method of unitizing pallet loads of 5/11-lb packages of wax in corrugated containers which promises a whole new approach to in-plant and intercity material handling as well as ocean transportation.

The technique brings the advantages of the strapped, taped or glued load to case-handling operations (1) at far lower costs, (2) with less damage to containers as the result of unitizing, and (3) without any necessity for special equipment or special procedures beyond the printer-slotter which produces the flat container blank at the box manufacturer's.

The clue is a permanent, invisible and very thin film of sprayable coating known as Paisley Non-Slip No. 1715 on the external surfaces of the top and bottom container flaps. These coated flaps — after the container is fabricated, filled and stacked — effectively prevent the skidding of one shipping container over another during the tipping, jarring, vibration, acceleration or deceleration which must be endured by palletized loads while they are handled or transported.

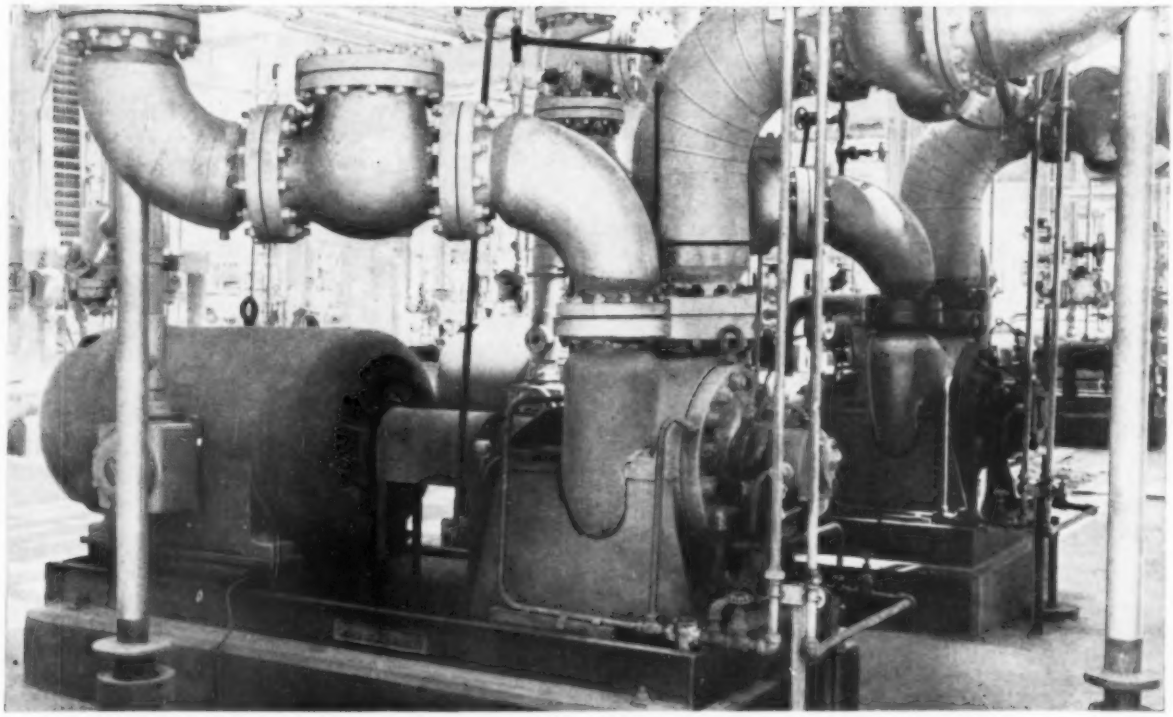
Nor is the technique valuable solely with palletized goods. Unitized loads for shipments handled by grab-truck or on sheets of corrugated stock without any pallet whatever can also benefit from the non-slip treatment.

Problem at Paulsboro

The most troublesome package from the slipperiness point of view handled on a pallet at the package division of the Paulsboro Socony Mobil Oil Company refinery is the 12 by 19½ by 8-in. case of either white or microcrystalline paraffin wax. The containers are filled with five 11-lb slabs, and stacked 40 units per load on a 48 by 48-in. pallet (4 tiers of 10 each as in Fig. 1C).

The load is transported over a ¾-mile unpaved route from the wax works to the package division warehouses, where it is handled and stored until delivery by fork truck to dockside or staging area for reloading into ships, lighters, freight cars, or truck trailers.

*These companies are: Socony Mobil Oil Company, Paulsboro; Paisley Products Division of Morningstar-Nicol; Hinde & Dauch Paper Company.



Two Ingersoll-Rand 300-hp Class CJVL solvent-circulating pumps in new reforming unit at Cosden Refinery, handling glycol at 1100 gpm.

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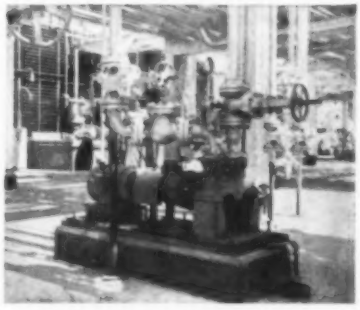
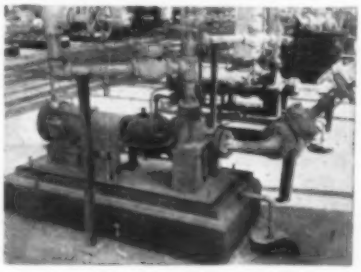


Ingersoll-Rand Class MFL pump transfers 90 gpm of high octane gasoline from Udex unit to storage.



Two Ingersoll-Rand Class BSFL pumps transfer bottoms on No. 2 tower to storage for Rexformer. Pump delivers 45 gpm.

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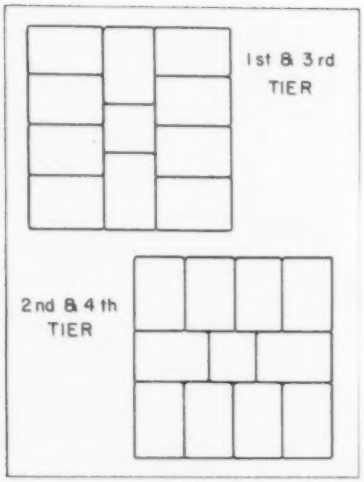

FIG.1C. Method of stacking boxes to "tie in" layers for greater stability.

The carton for the microcrystalline wax is glassine lined; the cartons for both types of wax are printed and styled as in Fig. 2. When filled they weigh about 35 lb each.

Transport from the wax works to the five-acre package division area is on the lowboy trailer shown in Fig. 3 and pulled by a shop mule. A full load consists of 10 pallets, two abreast, the forward pair being on the raised deck over the mule-lowboy coupling. Thus each trip moves 400 containers. Approximately eight trips are made per day.

Before the new carton treatment was applied, between 15 and 30 units per day were spilled and damaged during the ¾-mile trip, to the extent that the goods had to be returned to the wax works for remelting, recasting and repackaging. Prior attempts to solve the problem included staking the lowboy, using stringers along each side of the lowboy to tilt all pallets inward, the use of a trailer-train system, taping the load, and several patterns of load interlock. None were both sufficiently satisfactory and economical.

After arrival at the package division warehouses, handling is by fork trucks. Before the coating of containers with Paisley Non-Slip, operation of the fork trucks needed to be regulated at the abnormally low speed limit of two miles per hour when handling wax. It was even necessary to negotiate a five per cent ramp from warehouse to staging area by turning the truck around whenever wax was handled, and backing down the ramp so that the load leaned into the truck mast.

Today, with the non-slip containers, there is virtually no spillage in the transport from wax works to package division, a fork-truck normal speed limit of seven to eight miles per hour can be observed, and wax is taken head-first down the ramp at normal speed like any other product.

Fig. 1 shows a sudden-stop test with both filled treated containers (printed) and otherwise identical untreated containers (plain). The operator was instructed to slam on the brakes at a speed of five miles per hour. The results are dramatic. A maximum shift of three inches for the most displaced carton in the treated load can be observed. None spilled. The load stayed true. With the untreated load nine cartons were thrown to the dock from the top two tiers and the remainder of the load was displaced.

Had such an accident (formerly common) occurred from any appreciable fork height, all nine containers and their contents would have been damaged to the point of necessitating rework.

The wax containers are the worst actors of the 15,000 packages which division can handle in a day, because of the single-slab flatness of the bottom item in each. But even with shipping containers of oil and grease in cans (where each of the cans in the bottom

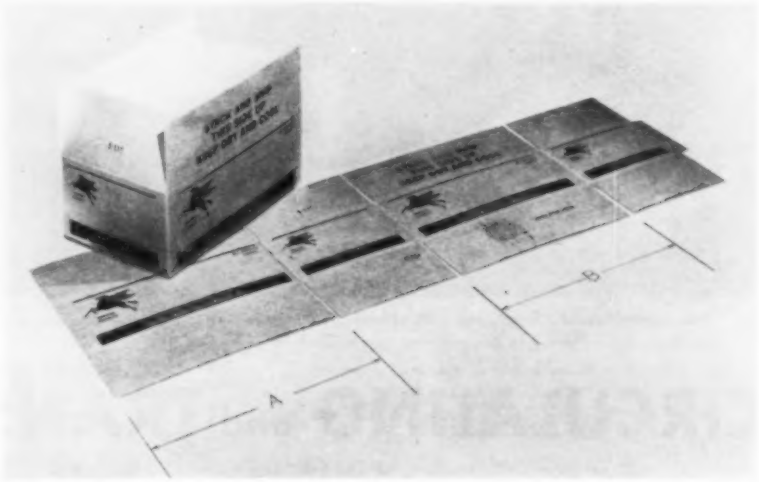

FIG. 2. Wax containers as employed in this test.

FIG. 3. Display of loading technique used in this handling-transportating test.

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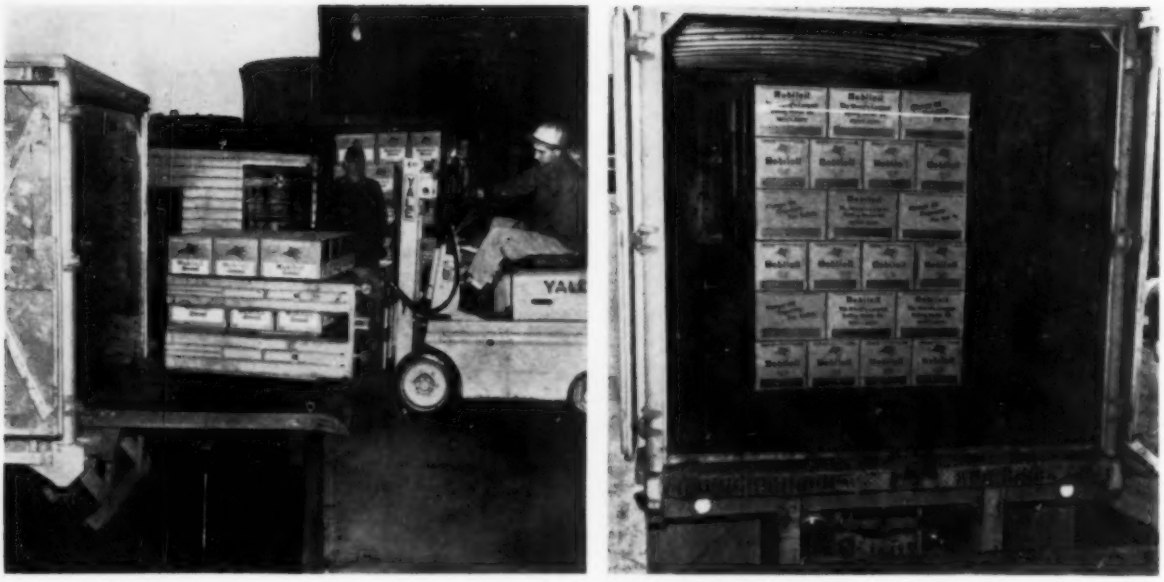

FIG. 4, A and B. Method of loading at Brooklyn packaging plant.

layer inside the package presses independently down on the lower case flaps so they could conceivably develop high and low spots to interlock with adjacent cases) trouble still occurred. So much so that from time to time the package division has experimented in many ways to alleviate the condition. Rougher board stock, glued loads and actually strapping and taping for warehouse handling were among those tried. Rougher board stocks did not work. Glued loads resulted in container disfigurement to the point of bad appearance or difficulty in later rebranding or marking. Strapping and taping required materials, tools and time which made the operation too costly.

Brooklyn-Albany Intercity Tests

Success at Paulsboro has encouraged the refinery engineering division to test the technique for the warehouse-to-warehouse shipment by truck-trailer of shipping cases containing 24 one-quart cans of oil and grease.

The most convincing tests were during the 150-mile Brooklyn-to-Albany run. The shipping units tried were unpalletized loads of the type shown in the drawings in Fig. 4E (three or four tiers high) handled by gripper-arm lift trucks and loaded down the center of the trailer. The individual boxes were 12 by 16 by 12 in. high. They were tiered tightly, 10 to a layer, with layers alternated for interlocking. Stacks were built both six and seven tiers high inside the trailer.

In the most revealing trials which led to the standard loading system now used, stacks were placed down the center of the trailer (a 32-ft box of 88-in. inside width) with 20 in. of clear aisle on either side. One total load was of 480 shipping containers (eight stacks each six tiers high). In a second run an attempt was made to build the stacks seven tiers high (560 containers total). Average weight per loaded case was 52 lb.

In the first trial two stacks employed no unitizing medium, this segment being the control and placed forward in the truck; three stacks were of cases treated (on the top surface only) with the non-slip material; three stacks were unitized with one band of pressure-sensitive filament tape applied around the top course of each stack.

Fig. 4A and 4B show the manner of loading in Brooklyn. Fig. 4C and 4D show the load on receipt in Albany at various stages of unloading.

J. A. McAuley of Refinery Engineering, said, after inspecting the load, "Examination upon arrival showed that eight top cases of the stacks not treated with any unitizing medium had toppled off to the right side of the truck (Fig. 4C); the stacks of containers treated with the Paisley Non-Slip coating were still in their original shape and position; loads unitized with filament tape also performed well in transit but not to the same degree as those treated with the Non-Slip coating." Fig. 4D shows the degree to which lateral vibration of the trailer had dangerously disturbed the three tiers below the top tier which was taped. If the road had been rougher or the trip longer the stack could have collapsed.

In the test run of 540 containers stacked seven tiers high, the entire load was treated with a spray coating, this time on both the top and the bottom of the case (as all wax boxes are now processed). The report was "While there was some lateral movement of this load, only two cases were damaged to the extent that repacking was necessary."

A conclusion reached by the report says, "Non-slip coatings on container surfaces apparently do as good if not better a job of unitizing loads as pressure sensitive tapes and unit gluing."

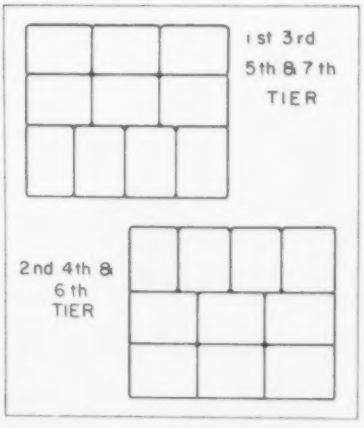

FIG. 4E. Method of stacking loads.

Coating and Its Application

Since the coating is applied by spraying and is required only on the top and the bottom of the finished and loaded case, there are many points in the complete packaging sequence where the job can be done. The shipper could coat in a relatively simple home-made machine that would treat the top and bottom of

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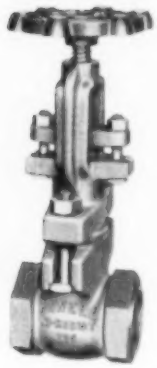

Fig. 2194—Small Ni-Resist O.S. & Y. Gate Valve for 225 W.O.G. Larger sizes, flanged end, and swing check valves in Ni-Resist also available.

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Fig. 1832—Stainless Steel Gate Valve for 200 W.P. Screwed-in bonnet, inside screw rising stem, solid wedge disc.

Fig. 2491—Stainless Steel Gate Valve for 150 W.P. Outside screw rising stem and yoke, solid wedge disc. Can be supplied with interchangeable split wedge disc

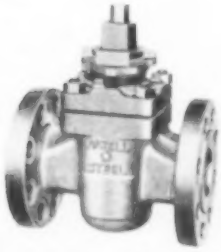

Fig. 1559—Steel Lubricated Plug Valve for 200 W.O.G. Screwed gland type. 6" and larger valves can be furnished for gear operation.

Fig. 1893—Large O.S. & Y. Gate Valve for Paper Mill Service. 3½ Nickel Iron Body, bonnet, yoke; stainless steel stem, screwed-in seat rings; Ni-Resist wedge.

Fig. 2433SS—Large size Stainless Steel Swing Check Valve for 150 W.P. Bolted Cap.

Fig. 2107—Stainless Steel "Y" Valve for 150 W.P. Plug type disc. Face to face and end flange dimensions conform to latest standards.

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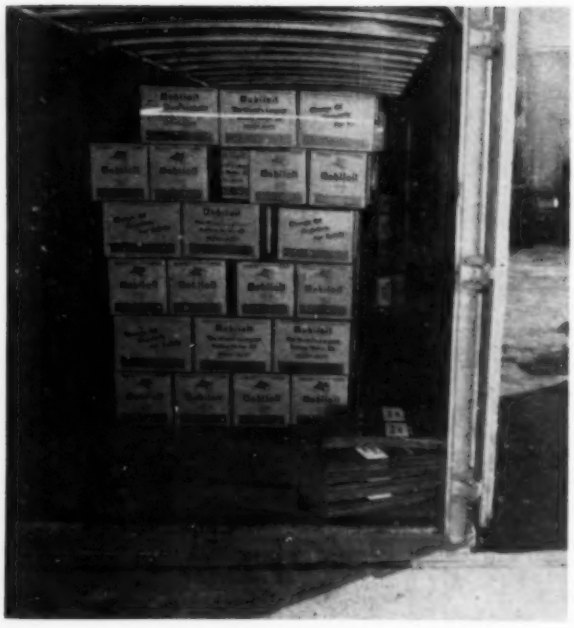

FIG. 4, C and D. Appearance and condition of loads upon arrival at Albany, in this long distance test.

the case at the end of the loading line. The sprays could be adapted to the case forming or case sealing unit. Or the containers could come already so treated from the corrugated box producer.

We selected the latter method as the result of joint development with Gloucester City plant of Hinde & Dauch Paper Company, and it was their decision to apply the coating at the discharge belts of the printer-slotter. This is possible since the sprayed film dries almost instantaneously and poses no difficulties in the later operations — stapling, storage or handling.

As a matter of fact the swipe of the sprays as the container blank shoots off the end of the printer-slotter cover the entire strips marked A and B in Fig. 2 so that the long side of the container as well as the top and bottom outer flaps are coated. Since the coating is undetectable except by the most sensitive feel, there is no necessity to block the spray off from any outer surfaces of the container.

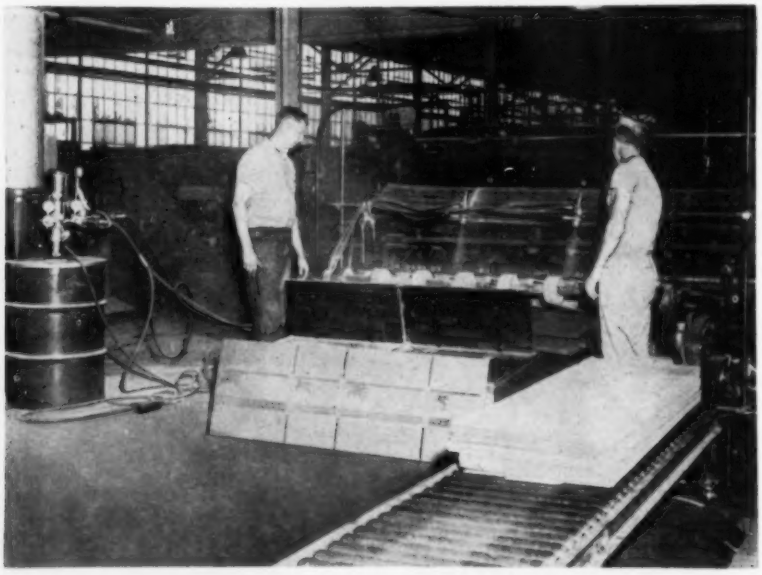

FIG. 5. The method and equipment for coating containers, installed in the box-maker's plant.

Fig. 5 shows the spray application setup at Hinde & Dauch.

Future of the Technique

The advantages of the technique over strapping and taping, (which require special tools and materials, and even more importantly, the time and technique for applying and removing them), and over the glued load, (which cannot but deface a container, if indeed it does not tear it, and which requires time and care for application at the point of making up the load), are both obvious. The great feature of a spray coating is that it can be applied by the corrugated box manufacturer as part of case production, and need not be thought of again by user, shipper, handler or dealer.

No material handling technique exists that does not have its limitations. Those which apply in this case must, it seems to us, be associated with extremes of lightness of case and contents, and extremes of vibration and jarring of unitized loads. What these limits might be we do not know. Further development and testing of the method should probably be directed along this line.

The cost factor, which is already minor, promises almost to vanish with widespread use.

As for problems at Socony with packaged refinery products during both in-plant and intercity handling, we seem to have solved the slipperiest and orneriest of our problems.

We hope that publication of our findings will prove helpful to others who may have similar problems. ★ ★ ★

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PATENTS were invented to protect the interests of individuals, and thus of the whole nation, by giving inventors a chance to realize on their original ideas.

XVI

V. A. Kalichevsky
Consulting Chemical Engineer

PEOPLE are fascinated with patents. "He will be a millionaire," they say when they hear that a patent was granted. This notion arises from the insufficient familiarity with the value of patents. The chances of becoming wealthy by owning a patent are more remote than the extra's chance of becoming a movie star.

The patent system of the United States is based on the Constitution of 1787. As a logical development of the Article 1, Section 8, of the Constitution, the Congress adopted the Patent Statutes in 1790 and the U. S. Patent Office was established in its own rights in 1836. The Patent Office issued the "Rules of Practice" for the applicants to follow. These laws and regulations are supplemented by court decisions which assist in their interpretations. The system is flexible. Both the Patent Statutes and the Rules of Practice are revised occasionally which affects the court decisions.

Patents protect interests of the individuals, not those of society. They are granted to provide incentive for making discoveries and thus stimulate the progress of science and useful processes by securing for limited times to inventors the exclusive right to their discoveries. This benefits society by keeping it active and protects it from its own stagnation.

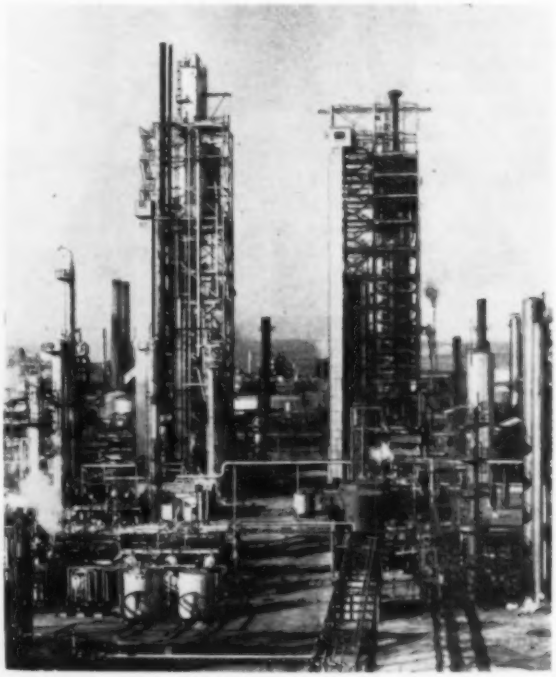
The right for a patent is given in exchange for the disclosure of the information which becomes public property at the expiration of 17 years from the date the patent was issued. During this time the patent protects the inventor from the possible attempts of other persons to commercialize his idea. The state is not interested in the matter beyond giving its assistance through courts in the settlement of disputes which arise between the interested parties. The same applies to any contract drawn between the individuals or concerns although the limit of such contracts must be defined to avoid misunderstandings. The patent litigations concerning infringements, that is trespassing on the rights and privileges of the individuals, are civil suits between the contestants.

Patent laws are by necessity complicated. Each patent case is decided on its own merit and this may create confusion in the interpretation of the verdicts. A layman's viewpoint, not that of a patent attorney, is presented here on the subject.

An invention must be commercialized before it brings an income. It must be useful to be of value. A person working on a practical problem is, therefore, interested to know what can be patented and what can be done with a patent if one is obtained. These questions appear simple but they are difficult to answer.

The inventor must decide for himself whether he has an invention and if he wants to patent it. When he makes the decision to obtain patent protection, he must prove to the U. S. Patent Office that he invented a new useful process, machine, manufacture, or composition of matter, not known or used by others. To a certain extent this is a reversal of the common law accepted in this country. The applicant for a patent must show evidence that he is not guilty of borrowing somebody else's idea when the examples of previous discoveries are presented to him by the patent examiner.

A law of nature cannot be patented: Its applications can. When Newton discovered the law of gravity, he was not an inventor. However, the law of gravity was applied for moving hands on the grandfather's clock by allowing the weights to fall down under controlled conditions, it was an invention although at that time the law of gravity was not yet discovered. The reason why the weights fall down



Patents, and the discoveries disclosed in them, and the research behind all of it made possible the advances in technology and techniques typified by the 'old' Thermofor catalytic cracking unit of the bucket lift type (right), and the 'new' Airlift TCC unit (left).

needs no explanation as far as the patent is concerned. When Moureu and Dufraise found the existence of inhibitors, it was not an invention. However, when they discovered that a small quantity of hydroquinone protects acetaldehyde from deterioration in the presence of air, it was an invention. Again no explanation is needed why it happens. Dufraise committed suicide when he saw that he stayed poor while others made fortunes by developing his original idea. This tragedy would have been avoided if he had known the patent law or had a patent attorney for consultation.

The U. S. Patent Office may not accept applications if they are contrary to the well-established laws of nature unless a workable model is submitted for inspection. This applies to the "perpetuum mobile" machines which are supposed to work without consuming energy. Otherwise, and that covers practically all patent applications, a description of the invention, preferably accompanied by a drawing, is sufficient.

With the above exceptions everything else might be patented if it is novel and promises to be useful to the inventor. It is often easier to obtain a patent protection on a wild idea than on a sound one because there are fewer chances that such an idea is already patented or that it will ever be contested. The inventor must decide for himself whether he wants to spend money for obtaining a patent.

What is new and what is old is not easy to determine even with expert assistance. The technical literature is vast and the number of patents issued in this country alone approaches the three million mark. The inventor should know if he has an invention because he is the person who should be familiar with the subject on which he is working. Actually no person is in a position to vouch whether the idea is original as this would require more than a lifetime study and the knowledge of a multitude of languages. The patent examiner assists the inventor by bringing his attention to patents already issued and which might cover the idea. The inventor may agree with the patent examiner and abandon the application, or disagree and present his arguments. This exchange of correspondence, which may be supplemented by oral discussions, may last for years. If the inventor and the patent examiner fail to reach an understanding, the inventor can present his case to the Board of Appeals, an institution within the U. S. Patent Department. Few patents are issued in less than two to three years from the date the application is filed. Occasionally 10, 15 and more years may go by before a patent is issued. This can be in favor of the inventor.

Assume that a patent application was filed when the demand for the invention has not yet developed. The patent is valid for 17 years from the date it is issued and during this time the possibility of collecting royalties could be small. By postponing the date of issue the inventor has the chance that his patent will be effective when the need for it is considerable.

The U. S. Patent Office is a governmental institution. It is immune to law suits. It cannot be held responsible for damages which might result from the refusal to grant a patent that could be valid. In order to avoid criticism for arbitrary actions, the patent examiners are inclined to make decisions in favor of the applicant and let the courts pass the final judgment on questionable issues. These courts may be civil courts after the facilities available within the U. S. Patent Office fail to bring the contesting parties to an agreement. In the civil courts the human rights to an invention are protected on a broad basis.

In some countries, like Holland, the patent examiners are strict. In other countries, like France, patents are merely registered without being examined or even read. Identical patents may be issued to different persons and registered side-by-side. The complexity of the problem forces the patent examiners in this country to choose the middle road but closer to the French than to the Dutch system. A patent may thus be regarded no more than a permit to sue a person who may infringe it.

The available literature on the subject covered by a patent is often sufficient to build up a case for and against validity of an invention. Opinions were expressed that a clever patent attorney can develop a perfectly good line of arguments in support of the patent and then tear it to pieces. The ease with which this can be done increases as the time goes by and more technical and scientific information accumulates in printed form.

Most of the patents are improvements on the former technique. The number of basic patents, that is patents which are essential for commercializing an idea, is extremely small. It is said that Adam was the only person who had originality and that his descendants elaborated on his ideas. It is often possible to use different roads for achieving the same aim and this explains the existence of competitive processes, all of them covered by patents. None of these patents, even if they are basic with respect to a process, are exclusive as far as the rest of these processes are concerned. Granting of patents increases rather than reduces competition within the industry under the present conditions of technical development.

Competition between the patented processes may be illustrated by the following example. Assume that a refiner is interested in separating aromatics from the non-aromatic hydrocarbons. At least three major avenues of approach are open to him. He can choose solvent extraction, adsorption on solids, and azeotropic distillation. These general methods have numerous ramifications.

If he decides on solvents, he can select liquid sulfur dioxide, ethylene glycol, furfural and a large variety of others. The same applies to the adsorption and azeotropic distillation processes. Science shows that the choice between solvents, adsorbents and azeotropic distillation agents depends on economics and not on the inherent differences between these physico-chemical agents.

Adoption of one of these agents in preference to another is not based on its exclusive characteristics but on the relative cost of the process. A mere substitution of one solvent for another is not an invention but the conditions under which the substance is applied might be. If such a patent is granted, another solvent, adsorbent, or azeotropic agent can be easily found which would accomplish the same task. In this particular example it is not the basic patent covering the substance used in the process but a combination of "know hows" that is of commercial value.

Complications which might arise in determining the novelty of an idea may be of singular nature. For instance, the structure of many high molecular weight compounds is unknown. Experience with chemical compounds which are thoroughly investigated shows that by choosing different reactions the same substance might be obtained as the ultimate product. Different names can be attached to it and the derivation of these names may depend on the materials used and the hypothetical course of the reactions. This can be illustrated by the following simplified example dealing with methyl alcohol.

Methyl alcohol can be obtained by destructive distillation of wood and called "wood alcohol" as most people know it. It is also produced on oxidizing methane and can be referred to as "methanol." It is formed on hydrolyzing methyl chloride with water and the name "carbinol" may be attached to it. Methyl alcohol is a low molecular weight chemical and can be easily identified. However, if its structures were unknown, as it happens with many high molecular weight substances, it would be impossible to conclude that methyl alcohol, wood alcohol, carbinol and methanol are identical. A smart organic chemist might "prove" that a compound on which he is working has a different structure than the same compound discovered earlier but assigned

Every step in the process of this polyolefin resin plant of Cleanese Corporation near Houston, Texas, is protected by patents, to guarantee the patent owners the right to the advantages of their discoveries for a term of 17 years.

some other formula. A costly and lengthy study is needed before the judgment can be passed that such compounds are identical and that they cannot be patented separately. Without such studies patents covering the use of the same substance in disguise and for the same purpose might be issued without realizing that an infringement exists.

Another complication is connected with the changes in patent laws. These changes are inevitable with the progress in science and industry but they may be confusing to a person who tries to determine whether he has an invention. Patent examiners and courts must have fixed rules for evaluating the novelty of an idea. These rules are revised from time to time. As a result the idea which can be patented at one time might be rejected at some other time.

A quarter of a century ago flowers and vegetables obtained by cross-breeding and other agricultural methods could not be patented. These plants, although artificially raised, were regarded as products of nature. This theory was abandoned and the "manufacture" of such plants is patentable now. Application of atomic energy for military purposes could be patented before 1946 but not any longer.

Still another example refers to the limits within which a patent may hold. In 1877, Friedel and Crafts patented the use of aluminum chloride for cracking, desulfurizing and polymerizing oils. Their patent was regarded as covering the whole field of the then known applications of aluminum chloride in petroleum refining. Some 40 years later dozens of patents on the use of aluminum chloride for the same purposes were granted. These patents specified preferred ranges for conducting the reactions. A very similar situation occurred with the patents covering the manufacture of isopropyl alcohol by the sulfuric acid process with the exception that the original idea was thoroughly described in a scientific paper. Changes that may occur in the interpretations of the novelty of an invention by the U. S. Patent Office should be known before a patent application is filed.

The inventor can prepare the patent application himself and present it to the U. S. Patent Office or engage a patent attorney. Familiarity with the patent laws is needed for obtaining a valid patent covering the widest possible range of utility. The first question that arises is "Who is the inventor?"

The inventor must be a person, not a corporation as other countries permit. He must be the originator of the idea. A person working under his directions is not an inventor unless he contributes something substantial in making the idea practical. If several persons are responsible for the invention, their names appear in alphabetical order, not according to the importance of their contributions as it used to be. Failure to include the name of the true inventor invalidates the patent. But who is the true inventor?

Assume that a certain person had performed a few experiments and could not interpret the importance of the results for securing patent protection. A patent attorney or a person connected with the search for patentable ideas cannot take out the patent in their names without being accused that they betrayed the person's confidence. The law of ethics demands that they abandon their personal claims to the novelty of the idea even if this might be contrary to the patent law. Similar considerations apply to the conscientious "line command." Another reason may also exist. If a patent is contested, the inventor cannot defend his case effectively because he is the interested party and his opinions might be biased. However, another person, thoroughly familiar with the patent, can act as a witness on the behalf of the inventor. For retaining his position as a witness, the real inventor might prefer not to sign the patent application himself if he can do it without arousing suspicion.

A thorough search of the literature including the patents is highly desirable before writing a patent application. This search establishes the novelty of the idea, permits its exact formulation, and suggests the scope of the invention. Unless such a search is made, the inventor may meet many disappointments even after the patent is issued.

The patent application consists of two parts: The specification and the claims. They complement each other.

The specification describes the invention in full, clear and concise terms which any person skilled in the processes or science must understand. It explains the principle of the invention, the best way of applying it to practice and the reason why the invention is novel. Specific examples of how the invention works must be presented. Drawings should be supplied whenever possible for clarity.

The claims follow the specification and are the heart of the patent. The specification may be regarded as an explanation of the claims. Each claim stands by itself and is independent of other claims. It may be considered as a patent within a patent. Winning or losing a claim by a court

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decision strengthens or weakens the patent but does not invalidate it unless all the claims are disproved. Every patent contains a few claims that are the most important. In patent suits these, and not all the claims, are usually attacked. If these claims are lost, the remaining claims may be so narrow in scope that the patent loses its significance.

Broad claims may precede or follow the narrow claims. Wording of the claims is an art. It must be done by using words which have clear legal meaning or are explained in the specification. Even punctuation marks must be watched carefully. *The importance of the manner in which the claims are written cannot be over emphasized.* Claims should not be misconstrued by any wild flight of imagination.

The following may be used as an example of errors which might be introduced in writing the claims even if wording and punctuations are correct. Assume that a person discovered that a stable oil is produced by extracting a raw distillate with a mixture of aniline and benzol. Such a claim might be open to question if no reference is made to the region within which the extractions are possible, that is the conditions under which two phases separate. This requires an explanation and definition of temperature limits, the relative quantities of solvents used, the type of distillate treated and other conditions of extraction. These limitations may still be insufficient if other patents were or could be issued in the future.

For instance, an earlier patent could have claimed concentrations of benzol in aniline "in excess of 20 percent." The new inventor discovered that better results are obtained if 10 percent of benzol is added to aniline. He may apply for a patent specifying extraction of the oil with aniline containing "10 percent" benzol. He can also claim aniline-benzol mixtures containing "less than 20 percent" benzol, or "from 10 to 20 percent" benzol. A third inventor engaged in the same work could have found that an unexpected improvement in product quality occurs when concentration of benzol is kept within the limits of "3 and 12 percent." These last findings would invalidate the claim for benzol concentrations "less than 20 percent" benzol because no improvement is observed if the concentrations are less than 3 percent. The same would happen with the claim "from 10 to 20 percent" benzol because the concentration of benzol should be less than 12 percent to obtain the improvement. The second inventor will thus be left with one claim for "10 percent" benzol while the third inventor can operate within the range of "3 to 12 percent" benzol with the exception of the 10 percent point. This concentration might be of little significance if it is not the best one to use commercially.

Another question often arises with respect to patents. Assume that a patent covers certain conditions of processing an oil distillate for improving the octane number of the product. Another person may find that these conditions improve not only the octane number but also some other property of the oil like stability. This does not entitle the second person to a patent because the range of processing conditions was covered by the first patent.

Some persons may deny it, but the patent language is not the same as the common written or spoken language. This is a natural development. The words in common usage rarely have a precise meaning and might be interpreted in several ways. The same words in the patent language can have only one meaning. Words like "substantially," "completely" and others of a semi-quantitative meaning may have exact quantitative legal interpretations attached to them on the basis of court decisions unless these words are explained in the specification.

The date of the invention is important if the priority of the invention must be established. This date should be recorded in the presence of witnesses. However, the date of filing the patent is very essential. Either date might be the deciding one in establishing priority of an idea.

An idea should be recorded but this does not mean that the U. S. Patent Office is committed to recognize the date of entry. The person who had the idea must prove that he believed in it and did his best to work on it whenever possible. Only then the date when the idea was conceived may be recognized in preference to the date of patent application. If time interval between the periods when the inventor worked on the idea exceeds the limit set by the U. S. Patent Office, it is assumed that the inventor became disinterested and is not entitled to the priority date.

The invention cannot be kept secret without losing the right of patenting it. Any process which has been in operation for over a year and for which the patent was not applied for, becomes a public property. If it were not disclosed in the literature, another person can patent it. However, the person holding such a patent cannot collect royalties from the person who had the process in operation before the patent was filed. Excuses are not accepted that the application for a patent was not made on account of personal ignorance. This would favor the use of secret processes.

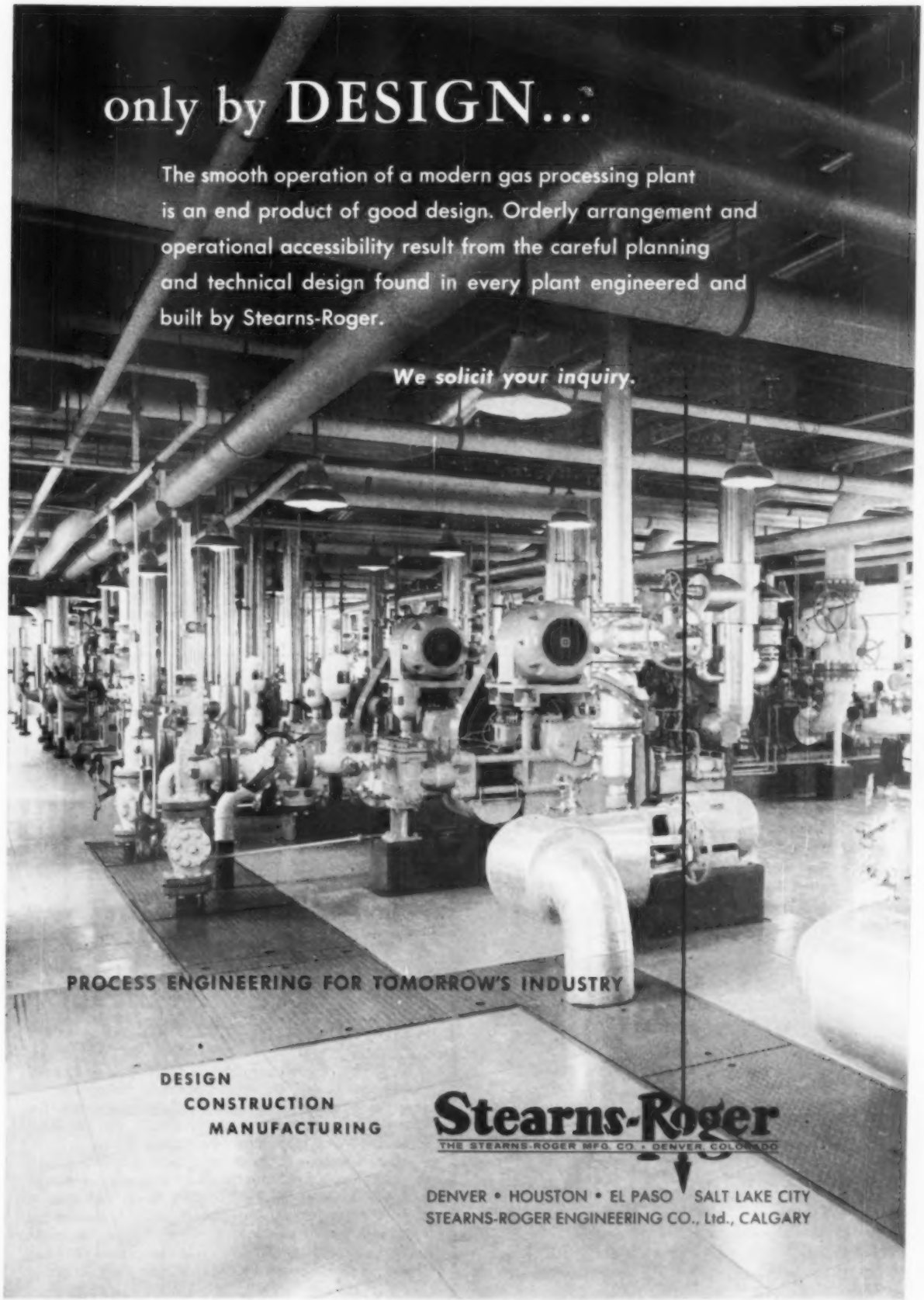
A patent is a property. It can be sold or royalties can be collected. The person who owns the patent must watch for infringements by other persons. If this happens, he can sue for damages. This has its drawbacks. Court proceedings are expensive and may ruin the inventor even if he wins the suit. One of the situations that may arise in this connection is as follows.

Assume that a patent was granted covering an object which is very easy to make in a small shop and at home. Many persons might start manufacturing the article without paying royalties. The owner of the patent must sue each of these persons individually. The money he might collect after he wins such suits may not cover legal expenses. As a result the inventor is the loser.

Whether we like it or not we must admit that court decisions are often based on the wishes of the majority of voters and not on the so-called absolute standard of truth. This is the difference between the common and the Roman laws of justice. A non-striker has little chance to obtain redress from a striker who attacked him. an insurance company is often forced to compensate persons who are guilty of negligence, a business enterprise has a hard time collecting damages done by the irresponsible employees whom it must keep because of the "fair practices" laws or union contracts forced upon it. The patent courts are not susceptible to such political influences. However, if no agreement is reached by the courts established for this purpose within the patent office, the patent suits can be tried in common courts.

Assume that an individual has a patent which passed all the trials and is found to be valid. The problem arises as to what can be done with the patent. The inventor can sell it if he finds a buyer, or he can organize a company using personal or borrowed capital for commercializing the idea. Sometimes a worthless patent might be bought by a large concern which could be cheaper than the expenses involved in winning a suit. This is about all that can be done with a patent.

The situation is different with the large concerns that are in a financially vulnerable position. They may have to take out patents, even if they are worthless, for defensive purposes, as a protection from suits that might be brought against them. In either case, be it an individual or a company, the decision must be made whether a patent application should be filed. The number of patentable ideas appears unlimited and without making such selections no resources of the world could be sufficient to patent all of them.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Charge Accumulator Pressure Relief Increases Tower Throughput

Here's an idea that won its originator, O. R. Harwell, an award of $1000 from his employers, Phillips Petroleum Company. Light hydrocarbons in the crude oil charged to a combination crude and cracking unit was causing pressure build-up in the fractionator, thus keeping throughput significantly below maximum operation. Rather than install a costly prefractionator ahead between the charge heat exchange train and the process furnaces, a pressure control valve was installed on a crude charge accumulator ahead of the furnaces.

The vapors in the accumulator flow through the pressure control valve in an 8-in. line to the overhead vapor line of the tower, then to the overhead condensers. Lowest permissible pressure on the line is 8 psi; opening or closing of the control valve, of course, lowers or raises accumulator pressure. Contrary to original conditions, the lighter the crude, the more that can be charged to the unit.

Insulation Installed Ten Years Ago is 89 Percent Reusable

At The Texas Company's Eagle Point Works, New Jersey, tank farm, 10-year-old sectional magnesia insulation was salvaged from relocated piping and reapplied to new lines to help reduce the cost of a recent expansion program. Workers are shown here applying new pipe insulation after depleting the supply of used magnesia.

Jeep Rescued From Junk Heap Makes Mobile Pumping Unit

A 108 years from now, when the popular mode of transportation will be atomic-powered helicopters or something, someone will still be finding new uses for jeeps — the real heroes of World War II. For old jeeps never die — and they seldom fade away either.

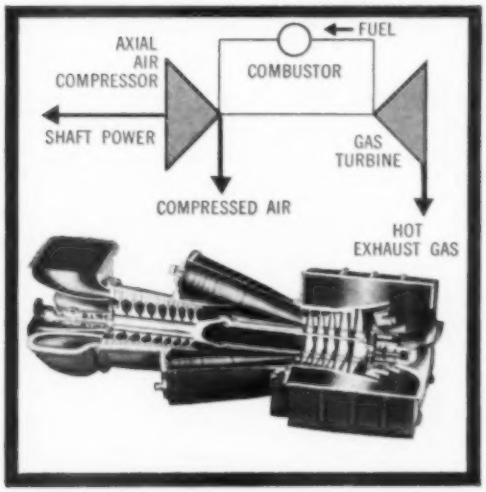
Here's one that probably saw more campaigns than six generals, yet it is still at work. A contractor removed its driveshaft, seat, and a few other things and made a portable pumping unit for utility work. The centrifugal pump is mounted so it can be driven by the venerable jeep engine, and a trailer hitch was clamped to the front wheels so the unit can be hauled from place to place.

3 FROM 1

Shaft power, compressed air, heat... all from one gas turbine...

BY TAKING ADVANTAGE of the versatile Westinghouse gas turbine, engineers are simplifying many processes. For example . . .

As gasifiers—In a large Southwestern butadiene plant, four Westinghouse gas turbines will soon be operating as gasifiers for the reactivation of the catalyst and each will eliminate the need for a separate prime mover and a separate air compressor.



In addition, smaller line heaters and less fuel will be used because *all* the *Btu's* put into the gas turbine are exhausted to the heaters and process, with the exception of minor radiation and bearing losses.

Versatility—The modern Westinghouse gas turbine can be used to streamline processes, for it offers many combinations of output:

Shaft power.....up to 22,500 hp
Compressed air.....up to 85 psia
Hot gas (18% oxygen).....up to 1000°F

Ask today for your set of suggested process sketches. Contact your Westinghouse representative, or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-50598

YOU CAN BE SURE...IF IT'S Westinghouse

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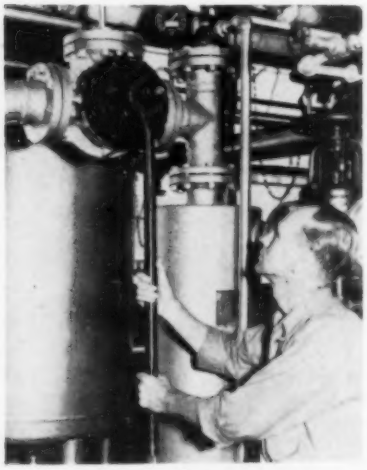

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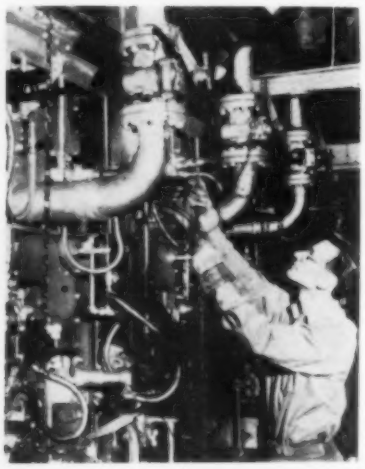

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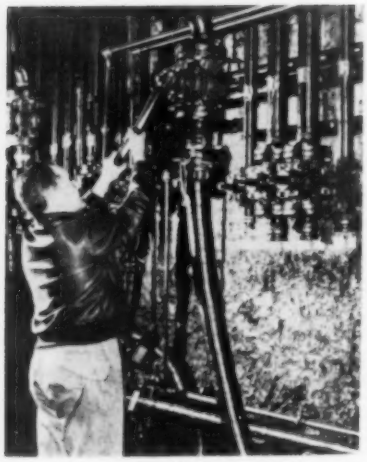

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4

Hard-to-Reach Valves?

Here are some Solutions

That bane of the maintenance man, the hard-to-get-at valve, is passing from the industrial scene in increasing numbers. The reason, according to Rockwell Manufacturing Company engineers, is lubricated plug valve design and a growing list of accessories.

Today almost any valve, whether overhead or underground, can be operated easily by a single workman. Some "hard-to-reach" valve solutions, based on quarter-turn action of the lubricated plug valve, are shown:

1. Overhead 3-in. lubricated plug valve in antibiotics plant is operated by a quarter-turn of the wrench extension.

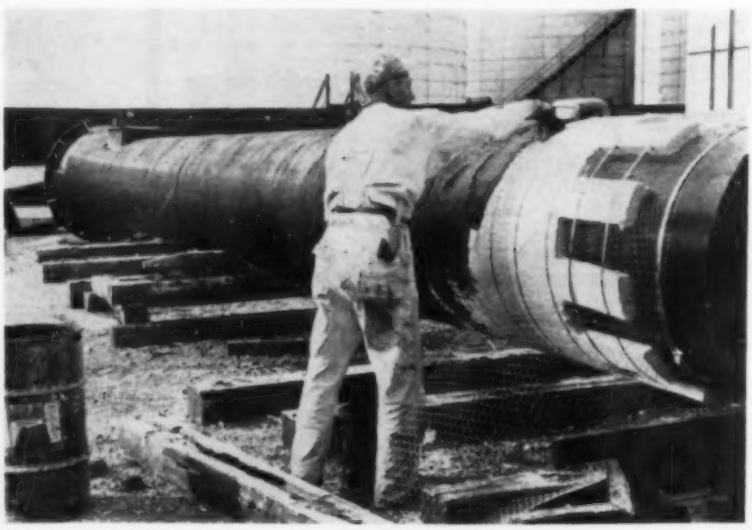
2. Small 1-in. lubricated plugs used as gas cocks on front-fired boilers are adapted to chain operation.

3. Small wrench is all that is necessary to operate this valve in products distribution system from full open to full closed in a quarter turn. Compact design of lubricated plug valves allows tight manifolding of other lines at convenient eye level.

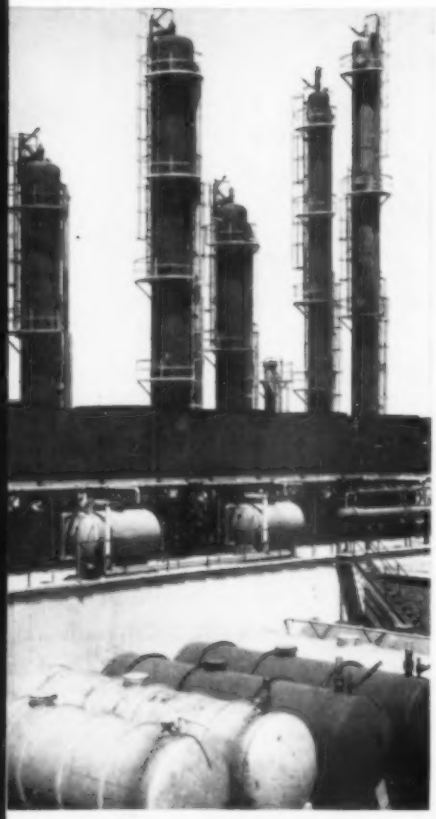
4. This underground valve is equipped for operation from ground level by high stem extension. In service on a gas pipeline, this 800 lb gear-operated lubricated plug valve was installed in its water-tight housing 28 years ago.

Cost-Cutting Insulation Technique

By insulating boiler smoke stack prior to setting on its permanent foundation, engineers of the American Bitumuls & Asphalt Company's Cincinnati, Ohio, refinery eliminated need for scaffolding, cut costs on the job to a minimum. Shop fabricated stack was set on blocks and insulated with two 1-in. magnesia blocks held in place with stainless steel bands placed 1 ft apart. Surface was covered with 1-in. No. 19 galvanized poultry wire which served as a lath and reinforcement for application of a cold-applied asphaltic protective material. Material was troweled on in two thin layers. After curing, stack was lifted at top by a crane and lifting lugs and set on foundation.



Almost everything you see here is **STAINLESS STEEL** ... Celanese Corporation plant uses **1,300 tons** of it



CELANESE CORPORATION'S Pampa, Texas, plant was built in 1951. It produces acetic acid, acetic anhydride and related compounds by the air oxidation of liquefied butane. Briefly, the butane is oxidized in the reaction unit, transformed into acetic acid and other compounds which are fractionated in the purification unit, then further processed.

Throughout the entire process from the reaction units to the finishing operations, *Stainless Steel is used almost exclusively for process equipment and piping in contact with the product.*

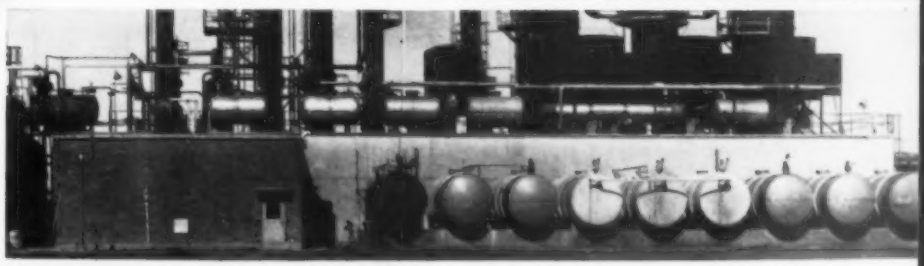
Some 1,300 tons of Stainless were used in the original plant. Since then, expansion has added hundreds of additional tons. All the equipment is *solid* Stainless Steel, mostly Types 316 and 317 welded with Type 317 rod.

Management feels that Stainless Steel plays an important part in the smooth, efficient operation of this plant. Failures are few and predictable, in contrast to other materials that may fail disastrously and without warning.

Because of its reliability, Stainless was installed here *at the beginning*, and it has paid its own way, over and over again.

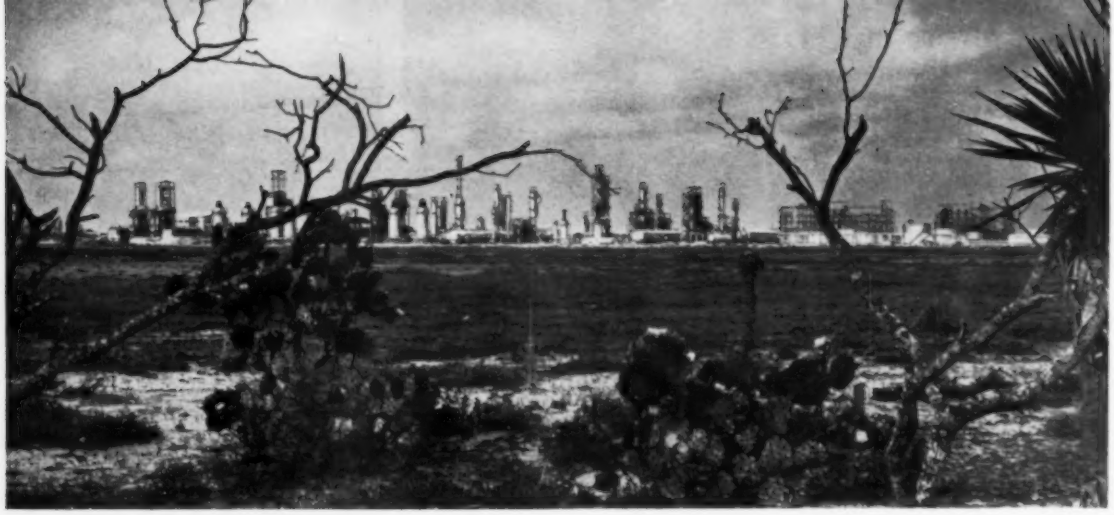
United States Steel Corporation, Pittsburgh
American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco
National Tube Division, Pittsburgh
Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York

SHEETS • STRIP • PLATES • BARS
BILLETS • PIPE • TUBES
WIRE • SPECIAL SECTIONS



USS STAINLESS STEEL

UNITED STATES STEEL



P 792.

Economic Factors Dictate Shutdown of World's First Gas Synthesis Plant

Amoco Chemical Company's Brownsville plant was a technical success, would ease the way for possible future installations

AMOCO Chemical Company and its parent company, Standard Oil Company (Indiana), can claim at least a moral victory, despite the permanent shutdown of the Brownsville, Texas, gas synthesis plant. The company says that the plant was closed on September 13 because "the process cannot produce gasoline and chemicals from natural gas as cheaply as they can be made by other processes." Most of the original problems that caused initial shutdown of the plant in June 1953 by its original owners — Carthage Hydrocol, Inc. — had been solved to commercial satisfaction.

The plant was originally completed in 1950 by Carthage Hydrocol, and operated intermittently until June 1953, when Carthage threw in the towel. Although designed to produce 6000 bbl of gasoline, 900 bbl of diesel fuel, 200 bbl of fuel oil, and 300,000 lb of chemicals daily, the plant never achieved more than 30 percent of design capacity, and shutdowns were frequent.

In December 1953, Pan American Petroleum Company (formerly Stanolind Oil and Gas Company) acquired an option on the stock of Carthage Hydrocol, picked up the option in March of 1954. The plant became a part of Amoco Chemicals Corporation in January 1957, in a consolidation of three chemical affiliates of Standard Oil Company (Indiana) in to Amoco Chemicals.

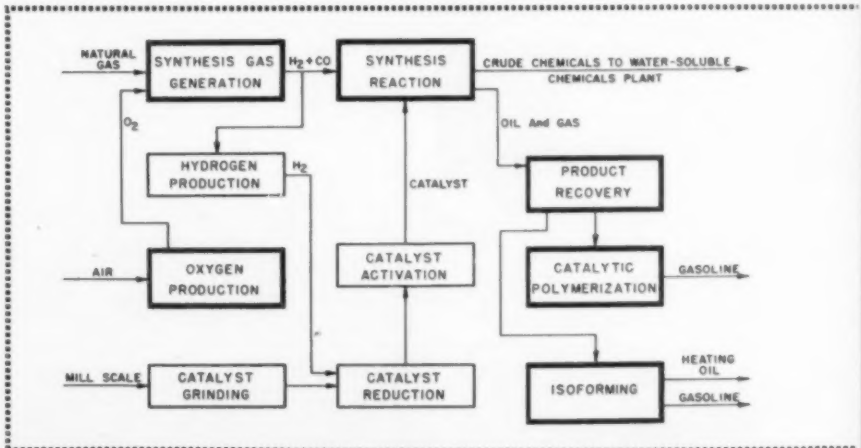
Pan American purchased the synthesis gas for two reasons: First, to protect its investment in an adjacent chemicals plant, and second, because of belief that their know-how on the basic synthesis process would enable them to achieve satisfactory operation.

In addition to buying the synthesis plant, Pan American also purchased from U. S. Industrial Chemicals Company, adjacent shipping facilities that were being used by USI to market the products from Pan American's chemical recovery plant.

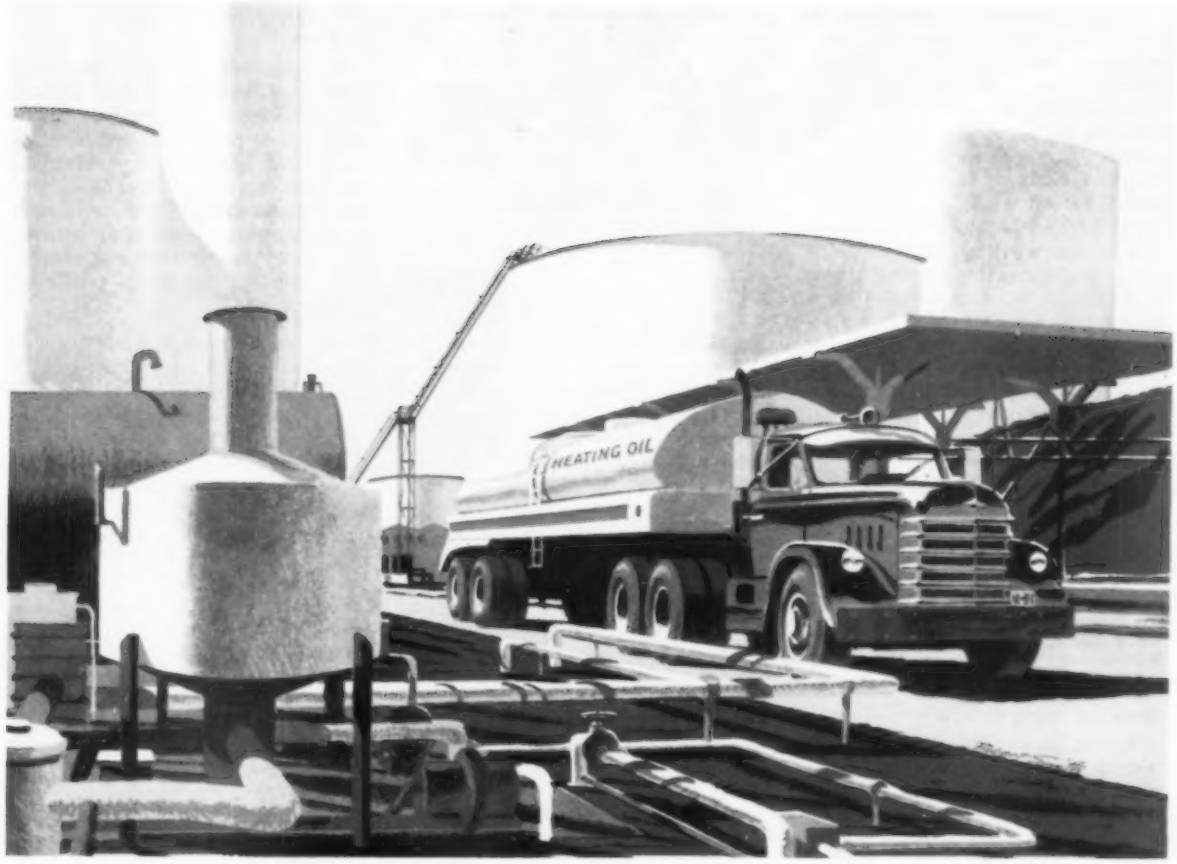
Operating Problems

At the time of shutdown, all sections of the plant had been in operation for a year or more, following an extended period of engineering and construction from the time of purchase. And, although some important technical problems were encountered after the revisions, most were solved in a comparatively short time. The most difficult problems were found in the synthesis reaction section, including mechanical failure and poor operation of the filters used to separate entrained catalyst from the reactor effluent gases, and low gas-solids contact efficiency in the reactors.

Filtration problems were solved a few months ago, when a new-type filter



Flow diagram for Amoco's Brownsville, Texas, gasoline-from-natural gas plant.



Want more heating oil sales?

Then try this formula . . . FUEL OIL + FOA-2 = sludge-free systems, consumer satisfaction

Really satisfied fuel oil customers—industrial or home-heat—are those whose heating systems function efficiently month in, month out. No costly downtime for tank entry to clean out sludge for industrial users. No clogging of the system, no additive-caused ash deposits to hamper electrical controls for consumers large or small.

Du Pont Fuel Oil Additive No. 2 minimizes these difficulties—even cleans out systems already near the fouling point because of sludge. FOA-2 disperses sludge in fuel oil, holds tiny particles in fine suspension and prevents sludge accumulation.

FOA-2 is ashless

FOA-2 being a nonmetallic additive, burns completely, leaving no ash to interfere with the operation of ignition and stack controls. Because of this, it does not contribute to chimney deposits and the possibility of puff-backs.

For best results, Du Pont FOA-2 should be added to freshly prepared stocks at the refinery. Small amounts are enough to protect most stocks from sludge . . . insure cleaner burning . . . prevent nozzle and filter fouling . . . and *keep* the burner system clean.

In this way FOA-2 keeps burners *burning*, keeps customers satisfied.

New FOA-2 booklet

Write for a copy of our new booklet on FOA-2 just off the press. It is amply illustrated and gives information about physical properties, applications, performance data and methods of addition.

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Better Things for Better Living
. . . *through Chemistry*

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medium — consisting of glass fibers in conjunction with carbon steel — replaced the porous metal originally employed.

At the time of shutdown, reactor operating factor was about 60 to 65 percent, and considered acceptable "for this particular stage in the process." However, a smaller reactor normally used for activation of the iron catalyst with synthesis gas, has been revised to demonstrate technical beliefs on attainment of better gas-solids contacting, coupled with reduced catalyst losses. Several runs in the modified activation unit, which was eight feet in diameter as compared to 16.5 ft for the two regular reactors, showed that significant improvement was commercially possible.

Results of typical runs on the commercial and "test" reactors were:

	Commercial Reactor	"Test" Reactor
Run length, days	50	100
Feed, % of design	100	100
Av. yields, % of design	—	—
Water-soluble chemicals	90-95	103
Stabilized oil	80-85	92
Polymer gasoline	80-85	93

Original Modifications

At the time that Pan American bought the Brownsville plant, a two-phase program was initiated. The first step was to complete modifications and additions needed to demonstrate operability of the process, with the expectation that operations would not be profitable. The second phase, predicated upon ability to demonstrate operability, would have been expansion of the plant to a level which would result in satisfactory return on investment. Major changes during Phase 1 included:

Oxygen plant. Each of the two oxygen plants — the world's largest — have a capacity of about 1000 tons daily of 95 percent oxygen. Major changes to the Carthage installation was repair of insulation for greater thermal efficiency; had limited production to about 75 to 80 percent of design. Also, the heat exchanger system was modified and expanded.

Synthesis gas generation. Heart of the plant, the synthesis gas section was used to partially burn natural gas with oxygen in the presence of fluidized iron catalyst at 300 psi and 2500-3000 F. Pan American added a second reactor to the single-reactor Carthage system to provide better continuity of operation. Also, the burners and burner control systems were considerably revised to minimize burner failures and soot deposition, and to have better control of combustion temperatures. High combustion temperatures had caused extensive metal and refractory failures.

Catalyst preparation. The catalyst plant includes units for grinding, sizing, and chemical impregnation of powdered catalyst, followed by reduction with hydrogen and treating with synthesis gas. The raw material for the catalyst was derived from steel mill scale.

Changes were made in the catalyst reduction reactor, which operated under fluidized conditions. These included new reactor internals for better gas-solids contacting and a new filter system for recovery of catalyst fines from the effluent gases.

A new reactor for contacting the reduced catalyst with synthesis gas was installed by Pan American. With the exception of initial problems with the catalyst filter system, operation was satisfactory.

Product recovery. Roughly comparable to the absorption and stabilization plants common to refineries and natural gasoline plants, this plant caused no important problems. Corrosion difficulties were completely solved by installation of corrosion-resistant alloys, and by the use of inhibitors.

Isoforming. The 5000 bbl per day "Isoformer" is a fluid catalytic cracking unit for treating synthesis liquids. With only minor modification to the unit and its associated equipment, satisfactory performance was shown in all operations.

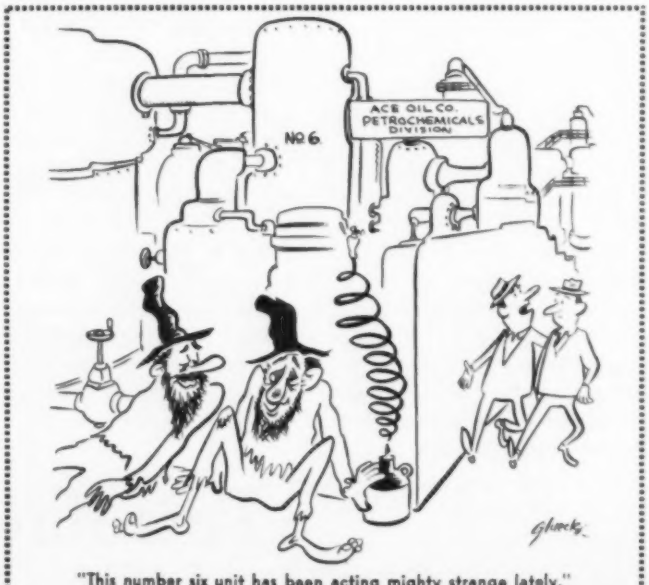
Catalytic polymerization. The California Research Corporation-design poly plant caused no technical problems. Important process and equipment revisions include three new stainless steel reactors, designed to operate at 500 psi, and additional storage facilities.

Water-soluble chemicals plant. Operability of the chemical recovery unit had been demonstrated by Pan American prior to plant shutdown in 1953. As limited by feedstock availability, the plant has since June 1956, produced acetic acid, propionic acid, acetaldehyde, propionaldehyde, acetone, methyl ethyl ketone, methanol, ethanol, isopropanol, n-propanol, isobutanol, and n-butanol.

Economic Factors Behind The Shut Down

The 1954 studies had shown that, given demonstrated operability, that expansion of the plant would yield attractive profits. Since that time, however, capital investment costs have increased by about two-thirds, due to increased labor and material costs. In addition, operating costs for the expanded plant would have been appreciably greater than predicted in 1954, along with some increase in the cost of natural gas.

At the same time, prices of gasoline and chemicals had not essentially changed. Current operations were not economical, and expansion along several alternate routes did not offer an attractive return. Decision: Ceasation of a costly $17.5-million alone in a guaranteed mortgage held by the Reconstruction Finance Corporation. But, should conditions warrant, Amoco Chemicals at least has the know-how to build an operable, technically feasible gasoline and chemicals from natural gas plant. Might come in handy some day. ★ ★ ★

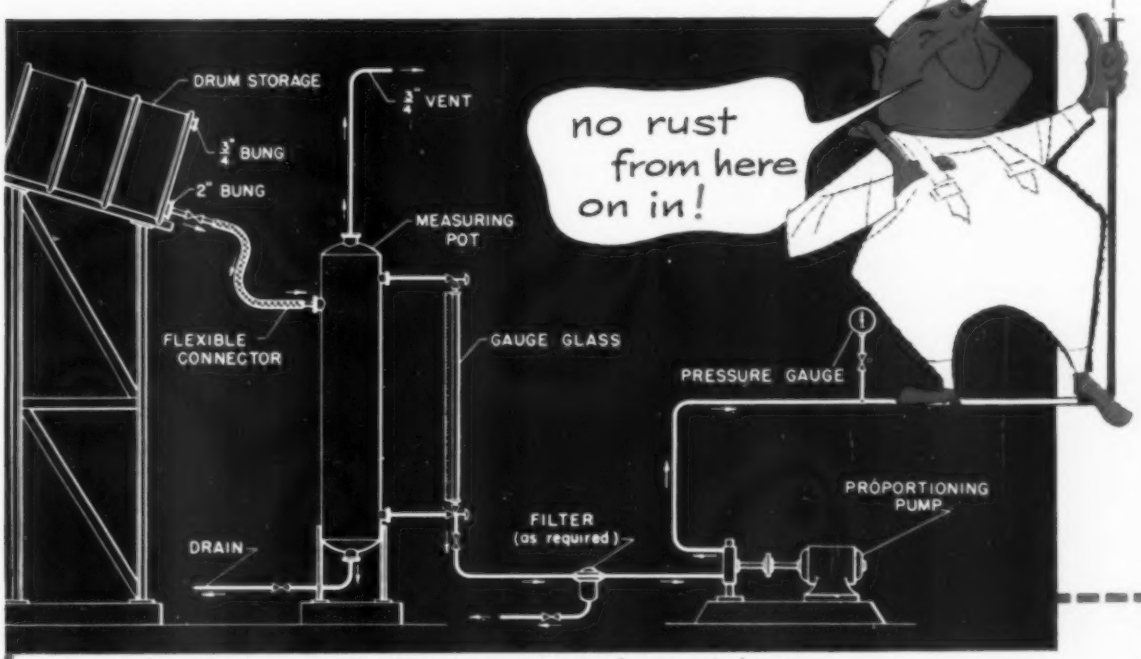


"This number six unit has been acting mighty strange lately."

If it's a question of corrosion...

UNICOR®

...is the answer



This is a flow chart showing how the Unicor Automatic Injection System works for you.

Question: *How can we eliminate serious filter fouling in blending tank caused by formation of highly peptized iron rust during processing?*

Answer: UOP's Unicor corrosion inhibitor solved this problem for a large southern refiner not long ago. Before Unicor application, a yard-square panel of the tank interior was sandblasted down to bare metal to test Unicor's effectiveness. After several months of injection in the rundown line, this test panel was completely free of corrosion, the remainder of tank interior was free of filter-fouling rust.

Question: *Is addition of water necessary?*

Answer: No. Unicor is oil soluble. It also prevents rusting caused by unavoidably entrained or dissolved moisture.

Question: *Should Unicor be injected only in the rundown line?*

Answer: Unicor can be injected at any point in your process. The refiner mentioned above shifted the Unicor injection point from the rundown line to his crude fractionator overhead and in catalytic gasoline from the main column overhead receiver. This extended Unicor's protection to heat exchangers, condensers and towers between new injection points and blending tank. Unicor inhibits corrosion in all your processing equipment from the point of injection on . . . even to consumer equipment.

Question: *How much does Unicor cost?*

Answer: About $0.001 or a tenth of a cent per bbl. of product in normal application.

Let us send you samples of

UNICOR

for testing in your own laboratories.

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L. E. West
Dowell, Incorporated

Hydraulic Jet Cleans Topping Unit Condensers

CLEANING coke-like scale deposits from crude preheater exchangers in topping units has been a problem for years. These oily deposits adhere tightly to the inner walls of the tubes and resist chemical removal. Sand blasting requires disassembly and extended outage of the unit. The problem has now been solved by employing a jet lance, a mechanical aid developed for use in specialized chemical cleaning applications. High velocity jets of water from the lance strike the deposit and remove it quickly and efficiently.

Equipment and Operation

Water at high pressure is pumped through the lance and into the tip where it emerges through a number of small orifices. Several of these orifices are aimed rearward. These jets serve the dual role of dislodging deposits and propelling the lance forward. Other orifices jet water forward to break up the deposits ahead of the lance. The lance can be readily modified to clean tubes ranging in size from $\frac{5}{8}$ in. to 1 in.

Each lance assembly consists of a number of lances 18 ft long mounted rigidly in parallel to a common header. This allows the lances to be inserted simultaneously in several exchanger tubes by a single movement of the lance assembly. The header to which the lance assembly is attached is connected to heavy-duty flexible hose through which the water is pumped at pressures as high as 4000 psi.

Time Requirements

In operation, the lance is inserted in an exchanger tube and thrust slowly forward as the high velocity jets escaping from the jet tip dislodge and disintegrate deposits from the tube wall. Little effort is required to guide the lance through the tube because of the forward push of the hydraulic jets that are directed toward the rear. The hydraulic cleaning method requires an average of only 24 hours outage. This represents about a 70 percent reduction of downtime on these exchangers, as compared to the sand blasting cleaning method.

Disassembly of equipment when sand blasting is to be employed requires removing the channel cover, the channel the shell cover, and the floating-head cover. The bundle must then be moved to a sand blasting set. Following the mechanical cleaning operation, the bundle must be reinstalled and headed up. Such a process keeps each bank of exchangers off the line for an average of about 80 to 85 hours.

Comparative Costs, Results

Table 1 compares the cost of cleaning each of two banks of exchangers in one topping unit. One bank was cleaned by sand blasting, and the other by hydraulic jetting. A single bank of exchangers was taken out of service and cleaned while the other continued in operation. The cycle was then reversed and the newly cleaned bank was put back in service while the other bank was shut down for cleaning. Thus, by cleaning one bank by sand blasting and the other by hydraulic jetting, comparative costs were obtained for a given set of operating conditions. Labor costs were calculated at $3.10 per man-hour, and the loss of throughput at 20 cents per bbl.

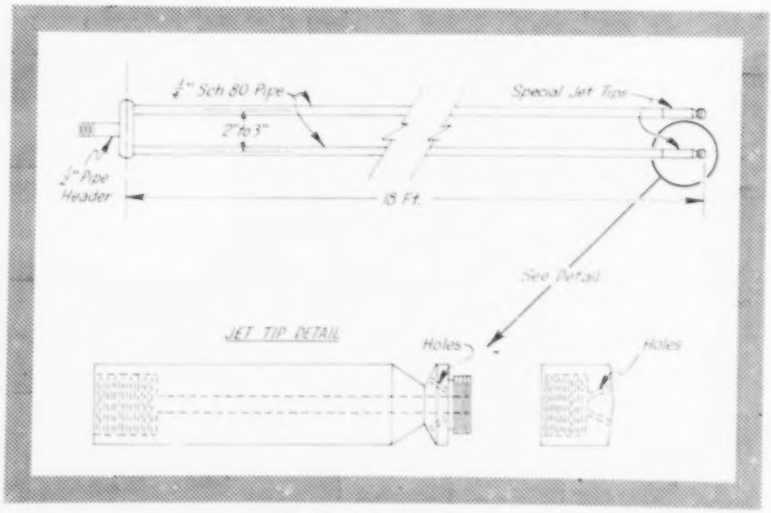


FIG. 1. Jet cleaning lance.

Based on the results of the calculations, it was concluded that the hydraulic jet cleaning method is more economical than the sand blasting method, and that the improved operating efficiency in terms of overall heat transfer coefficients following jet cleaning is about the same as for sand blasting. (Table 2.)

At present, research is being conducted on methods of using hydraulic jets to clean the exteriors of tubes and bundles. The possibility of using the jet process to clean vessel walls, trays, and bubble caps is also being studied. ★

TABLE 1. Comparison of Cleaning Costs.

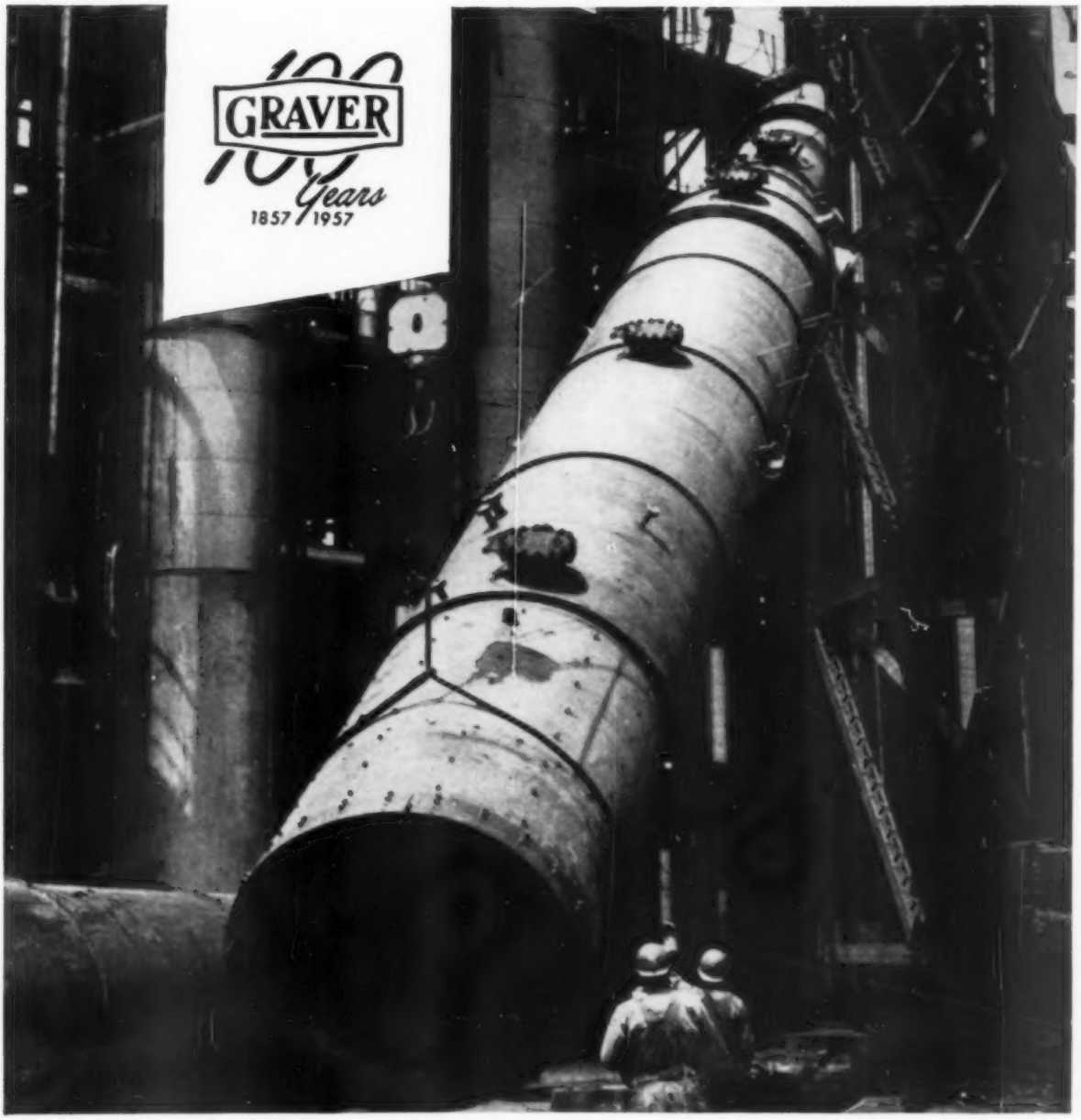
Method	Labor		Throughput Loss		Total
	Man hours	Dollars	Barrels	Dollars	Dollars
Sand blasting	1,800	$5,580	82,200	$16,440	$22,020
Hydraulic jet	264	$ 818	23,000	$ 4,600	$ 6,807*

*This total cost includes $1,389 for Dowell services.

TABLE 2. Improvement in Heat Transfer Coefficient.

Exchangers	Overall Heat Transfer Coefficient*		
	Before Cleaning	After Cleaning	
C-06	9.5	34.2	Sand blasting
C-104	25.2	64.0	" "
C-105	21.3	37.8	" "
C-106	15.7	33.4	" "
C-06	9.6	41.5	Hydraulic Jet
C-104	30.4	55.5	" "
C-105	25.9	41.8	" "
C-106	15.5	31.1	" "

*BTU per (hr) (sq ft) (deg F).



BIG GUN IN STAINLESS

Stainless steel so effectively turns the battle against corrosion that there is no question about the investment payout. To assure long life, Type 304 ELC stainless was selected for this 90' stripper column. Shop-fabricated by Graver in two sections and field-welded into one unit, the column was random-radiographed and tested to pressures of 162 psi. and 246 psi. Graver's expertness in fabricating and welding stainless is always assurance of trouble-free service.

to turn the battle against corrosion!

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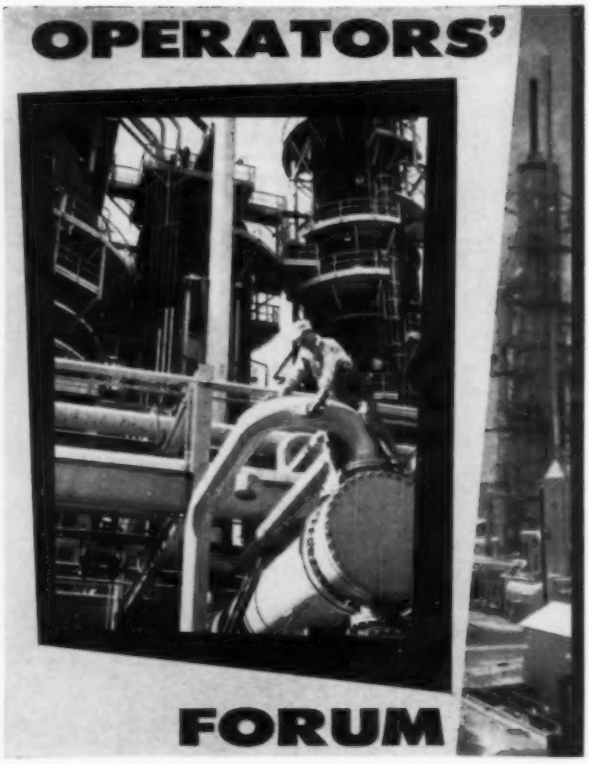
"Synthesis Gas" from Methane



$$-2O_2 (+ N_2) + CH_4 = 2H_2O (+ N_2) + CO_2 \quad . \quad (1)$$

$$O_2 (+ N_2) + CH_4 = CO_2 (+ N_2) + 2H_2 \quad . \quad (2)$$

$$O_2 (+ N_2) + 2CH_4 = 2CO (+ N_2) + 4H_2 \quad . \quad (3)$$

Q In the three equations above, (1) results in water and carbon dioxide, along with atmospheric nitrogen, with no hydrogen available for ammonia synthesis. What are the essential operating conditions that favor predominance of (2)? Of (3)? Which of these reactions is preferred in plant practice, and what are the main technical and economic reasons for this preference? **C. L. V.**

A In the preparation of synthesis gas by partial oxidation, reaction (1) is probably the way that oxygen is introduced to a series of complex reactions. The initial oxidation is extremely rapid and is highly exothermic. It is, therefore, the source of heat and is the driving force for subsequent reactions forming $CO + H_2$.

Reactions (2) and (3) do not take place to any extent, although (3) is a convenient way to represent the net effect of a number of reactions leading to the formation of the desired products.

The production of $CO + H_2$ probably takes place in two secondary reactions shown below, although the actual mechanism may be considerably more complex.

$$CH_4 + CO_2 \rightarrow 2CO + 2H_2 \quad . \quad (4)$$

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad . \quad . \quad (5)$$

These are relatively slow reactions with respect to (1) and are therefore rate controlling. They actually determine the operating conditions. In practice, only enough oxygen is added to combine with a portion of the methane present. The remainder reacts with the primary products of combustion to give the desired products.

When no catalyst is present, partial oxidation temperatures in excess of 200 F are required. Secondary reactions proceed rapidly, and approach to equilibrium is close. In the presence of a typical steam reforming catalyst, substantially the same results can be attained in the temperature range of 1700 F. The objective in commercial practice is to drive reactions (4) and (5) far enough to the right so that the methane content of the effluent gases is less than 0.5 percent by volume on a dry basis.

Partial oxidation is important in two plant operations extensively practiced in this country. In the first, or the conventional two stage steam reforming process, methane (natural gas) is initially passed over reforming catalyst held in tubes in the presence of excess steam. At about 1400 F 75 percent of the methane is converted to $CO + H_2$ along with a minor amount of CO_2. Air is introduced at this point, and combustion takes place in accordance with reaction (1) which raises the temperature to above 1700 F. Equilibrium conditions are now re-established by passing the partially combusted mixture through a bed of reforming catalyst. The air added contains the right amount of nitrogen for the subsequent ammonia synthesis.

In the newer Texaco partial oxidation process where no catalyst is employed, preheated methane and oxygen are fed into a specially designed burner where combustion takes place. The products reach equilibrium rapidly in a refractory lined chamber at temperatures in excess of 2000 F, after which the gases are immediately quenched in water.

There are two excellent articles in the literature which are recommended for study in this connection. These are:

Mayland and Hays, *Chem. Eng. Progress*, 45, 452 (1949), and D. Eastman, *Ind. Eng. Chem.*, 48, 1118 (1956).

Whitney Weinrich

Reliable, low-cost quality control with CEC's

PROCESS CHROMATOGRAPH

EXAMPLE: AVIATION GASOLINE...The three most popular alkylation processes use CEC's 26-202 Process Chromatograph for continuous monitoring of aviation gasoline quality. Finger-tip control allows treatment of end-product quality as another operating parameter, frees laboratory personnel for other projects. The 26-202 is the most practical system available today for remote control and recording, automatic sampling, automatic programming of recorded data, precise regulation of temperatures and carrier flow. *Contact your nearby CEC field office, or write for Bulletin CEC 1836-X14.*

Superior reproducibility and trouble-free, *continuous* service are provided by this completely transistorized two-unit system. Analyzer unit meets specifications for installation in Class I, Group D, Division I hazardous locations. Control unit, from its remote location, provides timing and control with precise regulation. Sample volumes are reproducible to better than $\pm\frac{1}{2}\%$. Sample and column temperatures are held within $\pm 1°F$. Variations in the carrier gas flow-rate cannot exceed $\pm 0.1\%$. Voltage regulation for the thermal conductivity cell is better than 0.05%.

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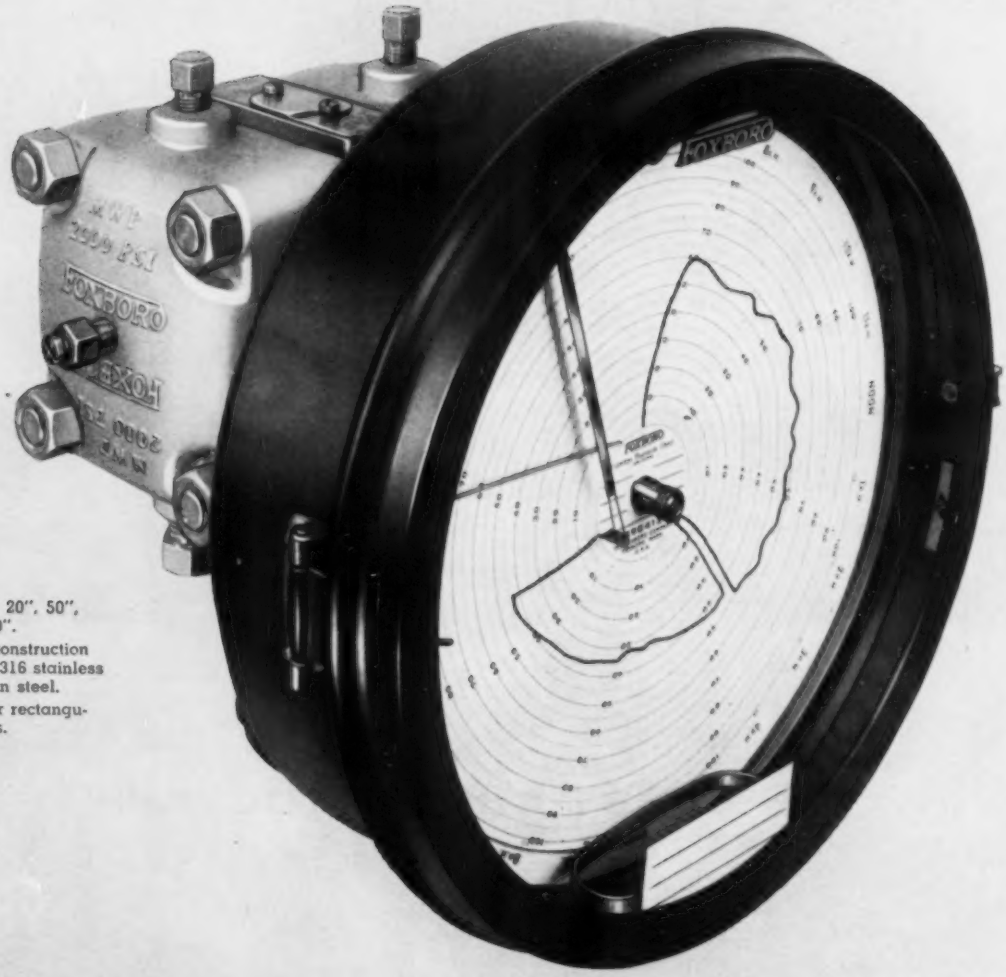
NOW... a "Dry" Flow Meter with..

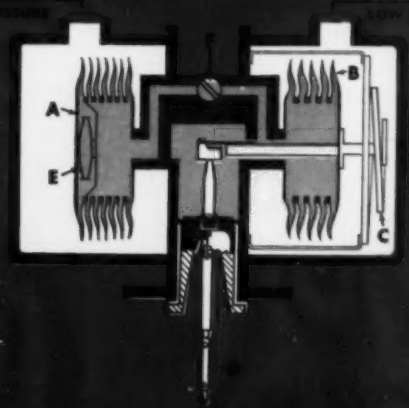


- Ranges: 20", 50", 100", 200".
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

...the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



• *complete overrange protection!*

• *sustained high accuracy!*

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before! The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all! Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges. Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write **The Foxboro Company, 6411 Neponset Ave., Foxboro, Mass., U.S.A.**

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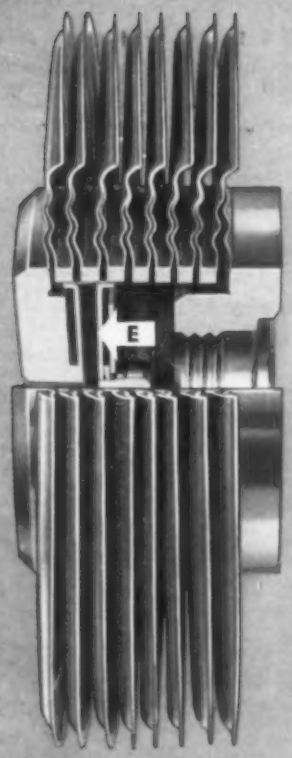
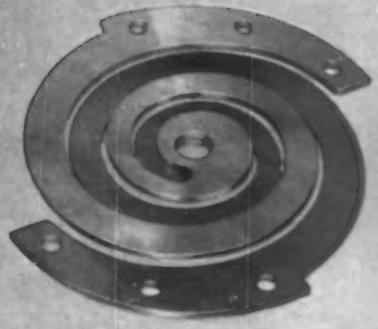
FIRST IN FLOW METERING



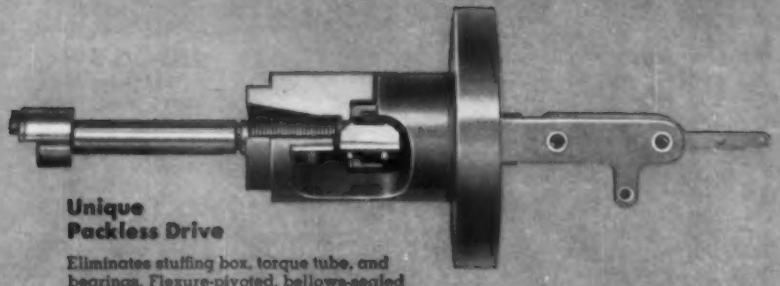
Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . *never* requires change or adjustment.



Exclusive Range Springs

Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!



Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity *and undiminished* power. Seal for flexure pivot is a tough, flexible bellows.

REFINING AND PETROCHEMICAL PERSONALS

Leroy B. Fox, manager of the fuel oil division of the gasoline and fuel oil department, Socony Mobil Oil Company, Inc., has been appointed manager of the asphalt department. He succeeds **George R. Christie,** who is retiring. Succeeding Fox is **Leonard S. Marshman,** who had been manager of the crude oil division of the distribution department of Mobil Overseas Oil Company.

Juergen J. Bloess, Baytown, Texas, and **Mark A. Halepeska,** Corpus Christi, Texas, have been appointed to the engineering staff of Great Northern Oil Company. Bloess, formerly associated with Humble Oil & Refining Company, Baytown, as chemical engineer, has been assigned duties as process engineer in Great Northern's technical service department. Halepeska is field maintenance engineer in the maintenance department.

T. E. DeVilliers of Gary, Indiana, has been appointed manager of the Cities Service Oil Company, Cicero compound plant and marketing warehouse-terminal at Chicago. The new appointment was occasioned by the transfer of **Don V. Eells,** present manager, to the company's headquarters office at Bartlesville as staff assistant.

Joe A. Keepers has been appointed senior project specialist in the development department of the Lion Oil Company Division of Monsanto Chemical Company. Keepers, who has been project specialist in the research development department of Monsanto's plastics division at Texas City (Texas) since 1953, transferred to Lion on August 1. In his new position he will continue to be stationed at Texas City.

H. H. Chandler, superintendent of The Texas Company's Eagle Point refinery at Westville, New Jersey, has been assigned executive duties in London, England, as deputy shareholder's representative. Chandler will be succeeded as superintendent at Eagle Point by **V. K. Brandenburg,** assistant superintendent of Texaco's Lawrenceville, Illinois, refinery.

The British American Oil Company has announced the following appointments in its manufacturing department:

H. A. Hornfelt is appointed construction superintendent of the company's Port Moody refinery projects. Most recently he was assistant manager of the company's Calgary refinery. **C. W. Coote** is appointed manager of the company's new refinery at Port Moody, British Columbia. Coote was manager of the company's refinery at Edmonton. **R. E. Harris** is appointed manager of B-A's Edmonton refinery, succeeding Coote. Harris was assistant manager of the company's Moose Jaw refinery. **J. L. Stoik** is appointed assistant manager of B-A's Moose Jaw refinery, succeeding Harris. He was operating superintendent of the Moose Jaw refinery.

Hamilton P. Caldwell Jr. has been named manager of Socony Mobil Oil Company's refinery in Augusta, Kansas. Caldwell, who has been manager of the oil company's refinery in East Providence, Rhode Island, will succeed **J. W. Glass,** who is retiring. **Joseph E. Penick,** supervisor of light oil operations in the oil company's manufacturing department, has been named manager of the East Providence refinery. **Bonner H. Templeton,** assistant manager of Socony Mobil's process promotion division, will succeed Penick.

John E. Morrow Jr. has been appointed special representative, industrial products department, Sun Oil Company. He succeeds **Dr. Archie B. Hoel** who has retired.

William F. Lowe has been elected executive director and treasurer and **Ronald E. Cannon** as secretary of the Natural Gasoline Association of America. Lowe has been secretary-treasurer of the association since 1934. Cannon was a technical editor for the McGraw-Hill Publishing Company with offices in Houston, Texas. He is a native of Beaumont, Texas, attended Tulane University and was graduated from Louisiana Polytechnic Institute in 1948 with a BS in mechanical engineering. Also, Cannon is a registered professional engineer in Texas and has been active in the petroleum division of the ASME.

R. E. Cannon

R. D. Meagher has been named assistant manager of The British American Oil Company Limited's Calgary refinery. Most recently he was head project engineer of the head office manufacturing engineering department.

Clifford V. Shireman has been named refining superintendent of The California Oil Company. He has served as a refinery foreman, as a research engineer in the company's process development division, and as a general foreman in the manufacturing division.

L. Edward Klein and **Dr. David T. Mowry,** both of St. Louis, have been appointed assistant directors in the development department of Monsanto Chemical Company's organic chemicals division. Both Klein and Mowry move up from section managerships within the department. Klein has been in charge of development work on intermediates and exploratory chemicals while Mowry has been responsible for fine chemicals development.

L. C. Kemp Jr. has been elected vice president in charge of The Texas Company's petrochemical department. He previously served as general manager.

Eugene S. Martin has been appointed superintendent of Shell Chemical Corporation's synthetic rubber plant at Torrance, California. Martin succeeds **G. S. Williamson,** recently named manager of Shell Chemical's ammonia plant at Shell Point, in the San Francisco Bay area.

A. L. Geisinger, vice president and general manager of the plastics division of Diamond Alkali Company since 1953 and a 38-year veteran with the firm, will retire at the end of the year. **James P. Okie,** assistant general manager of Diamond's plastic division for the past five months, will succeed Geisinger as general manager of the division.

A. E. Marshall Jr. and **B. R. Starzanski** have been named assistant managers of the process promotion division of Socony Mobil Oil Company's manufacturing department in New York City.

H. Harold Bible has been named vice president and assistant general manager of the Lion Oil Division of Monsanto Chemical Company. He was formerly director of manufacturing.

Dr. J. R. Morris has been transferred to The Texas Company's Port Arthur, Texas, research laboratories as assistant supervisor in chemicals research. He was formerly on the staff of the manager of research at the Texaco Research Center in Beacon, New York. **Dr. Warren G. Schlinger** has been transferred to Texaco's Port Arthur research laboratory as a project engineer in fuels research. He was formerly a chemical engineer with Texaco's research laboratory in Montebello, California.

Promotion of three key men to newly created positions in Continental Oil Company's petrochemical department has been announced. **J. G. Hough,** general superintendent of petrochemical manufacturing, promoted to assistant general manager of the petrochemical department. **Paul E. Geiser,** director of petrochemical product quality, promoted to manager of the department's detergents division. **W. B. Strobel,** director of petrochemical projects development, promoted to manager of the department's chemicals division.

R. L. Hockley of Baltimore, Maryland, a consultant in the chemical industry, has been elected to the board of directors of Amoco Chemicals Corporation.

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For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

IBM Announces Powerful Office Machine. The Data Processing Division of International Business Machines Corporation has announced the 705-III, one of the most powerful electronic systems on the market for the processing of business data. One of the outstanding features of the new system is a completely transistorized magnetic tape unit. This ultra-high speed tape unit, the IBM 729 Model 3, can read or write business information at the rate of 60,000 characters per second, automatically checking the information for validity and readability at the same time. By increasing tape density, the Model 3 is able to store up to 3 times as much information on each tape reel. *International Business Machines Corporation.*

Circle number (41) on reply card.

General Electric Announces Speed Variator. A new line of packaged adjustable speed drives has been announced by General Electric. Designed for minimum maintenance, the Speed Variators are available in ratings of 3 through 150 hp and in speed ranges of 8 to 1 and higher. *General Electric Company.*

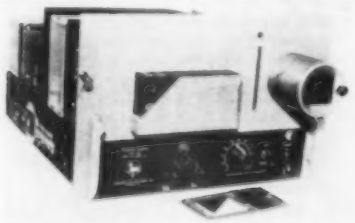
Circle number (42) on reply card.

Small Liquid Sample Cooler. A small, low cost liquid sample cooler has been designed for use with pressures up to 5000 psig and temperatures up to 1200 F. It is a shell and tubular coil type heat exchanger.

All parts of the cooler, which is housed in a stainless steel shell 3½ in. in diam. by 11¼ in. long, are joined by welding. Sample pipe and circulating water connections are all made externally to avoid the possibility of sample contamination from leaky joints and fittings. *Technical Engineered Products, Inc.*

Circle number (43) on reply card.

Instrument Converts Drawn Curve. A new non-mechanical instrument that converts a curve drawn on graph paper into a voltage to be used to program radiant heat, test load and other control, programming or computing applications, has been developed by Spar Engineering & Development. The all-electronic unit, known as the Program Scanner, begins operating when a photographic transparency of a curve is inserted in front



of the "flying spot" tube which is swept by a vertical line moved horizontally across the face of the tube. The scanner's output is available as a variable width pulse or dc, with ac output being obtained by adding a converter. Accessory items include an automatic camera to facilitate the making of transparencies, and time base generators to drive the horizontal sweep. *Spar Engineering & Development, Inc.*

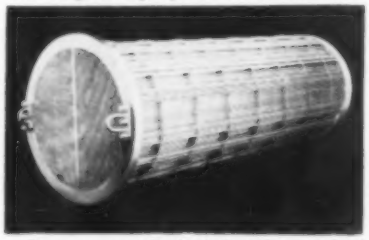
Circle number (44) on reply card.

All Glass Valve. An all glass Y-type valve which is impervious to corrosion has been developed by Corning Glass Works. Made of tempered Pyrex brand borosilicate glass, the 2-in. valve is corrosion resistant, compact, lightweight, tough and versatile.

All working parts of the new valve exposed to fluid are of glass or Teflon. Acidic fluids of all concentrations or compositions at temperatures as high as 250 F can be handled by the valve. *Corning Glass Works.*

Circle number (45) on reply card.

Cooler Has Space-Capacity Ratio. Schutte and Koerting Company have designed and fabricated an oil cooler which solves a problem with respect to cooling rate desired and the limited space available to position the unit. Process requirements called for the unit to handle 860 gpm of hot lube oil around the tubes, and 1600 gpm of condensate from a condenser through the tubes as cooling medium. Specifications required that 4,000,000 Btu's /hr be given up by the oil to the water.



Space was so limited that the required capacity was achieved by designing a cooler whose overall length measured only 134¾ in., and whose diameter was 37 in. In order to fit, the unit was designed to use ⅜ in. OD, 18 gage tubes—4018 of them in a bundle 120 in. long. The bundle weighed 5-tons, and the complete cooler, 8-tons. *Schutte and Koerting Company.*

Circle number (46) on reply card.

Duplex Model Pump. A new duplex model pump for precision pumping, feeding and proportioning of liquids at micro flow rates has been announced. The pump is Lapp Microflo Pulsafeeder "Model LD", designed specifically for pumping 2 liquids in equal volume or each at a different rate but in exact ratio.

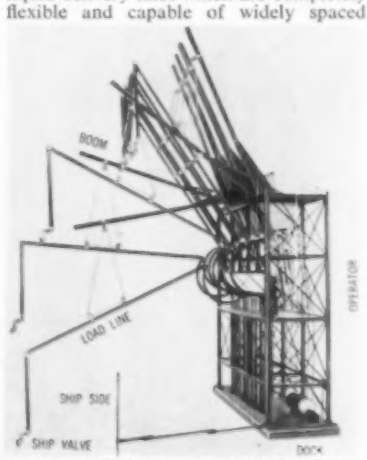
"Model LD" is an assembly of 2 piston-diaphragm pumps mounted side by side on a common base and having a single drive. Pumps have no stuffing box, packing gland or running seal to come in contact with liquid being pumped—the product is isolated from all pumping parts by a hydraulically balanced diaphragm and is protected from contamination and leakage to atmosphere. *Lapp Insulator Co., Inc., Process Equipment Division.*

Circle number (47) on reply card.

Check Points Monitored With One Unit. Any number of check points can be monitored by a single unit of a data logger engineered by Taller & Cooper, Inc. The electro-mechanical data logger is used to keep track of pressure, temperature, or any other measurable characteristic at any number of check points. *Taller & Cooper, Inc.*

Circle number (48) on reply card.

Automatic Petroleum Loader-Unloader. A new automatic petroleum loader and unloader for terminal and wharf is announced by the Mott Haven Equipment Company. Designed to fit any ship valve position and any tanker, it has hydraulically operated booms employing the Tripp "S-Boom" principle and suspended liquid delivery lines which are completely flexible and capable of widely spaced



cross-over. This 1-man operated unit can be set back-to-back with an additional unit as it handles hose pipes on ship side only and having no backward interference, the 2 units can therefore fit on a narrow finger pier to permit loading and unloading of vessels on either side of the pier simultaneously. *Mott Haven Equipment Company, Inc.*

Circle number (49) on reply card.

Ductile Iron Diaphragm Valves. A new line of ductile iron diaphragm valves has been announced by Hills-McCanna Company. This line has been developed to meet an industry-wide requirement for a diaphragm valve with exceptional strength and resistance to fracture and thermal shock. Valves cast of this material have the tensile strength of cast steel and approach the economy of cast iron as well.

These valves are available as complete valves or replacement components of bodies, bonnets and handwheels and are available with screwed ends (½-3 in.) and flanged ends (½-8 in.) *Hills-McCanna Company.*

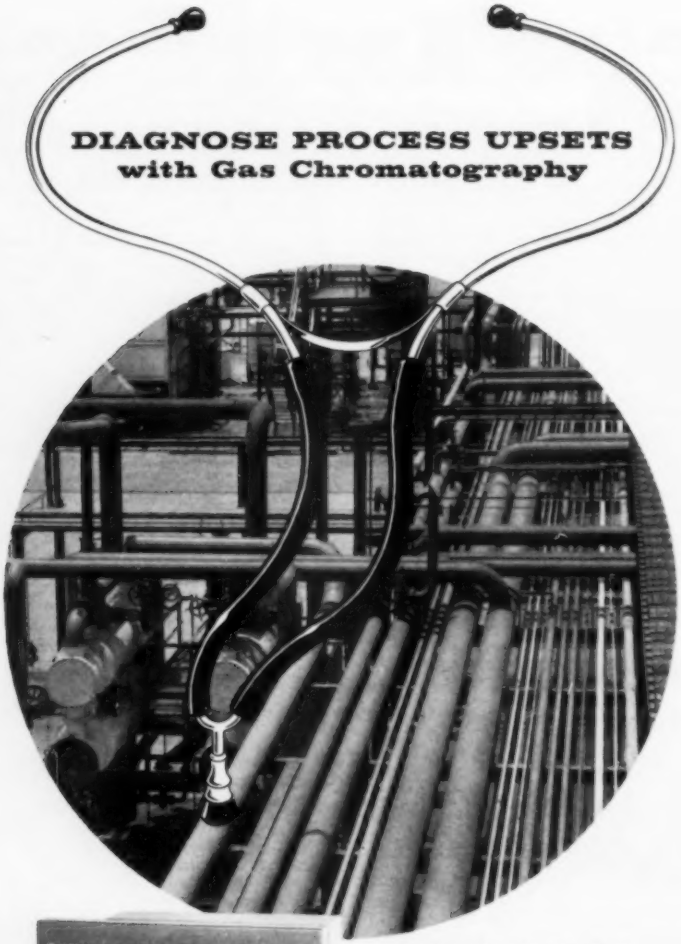
Circle number (50) on reply card.

New Magnetic Gage. Jerguson Gage & Valve Company announces a magnetic gage for the observation of liquid levels, especially designed for use where ordinary gages with glass, gaskets and threads cannot be tolerated due to dangerous inflammable or explosive conditions.

Safety against the slightest escape of dangerous gases is assured by the design which incorporates the gaging mechanism in a stainless steel chamber, mounts the special scale outside the chamber, and accurately indicates the level by magnetically actuating the scale through the chamber wall. *Jerguson Gage & Valve Company.*

Circle number (51) on reply card.

DIAGNOSE PROCESS UPSETS with Gas Chromatography



The Model 120 Industrial Gas Chromatograph automatically analyzes up to four components in single or multiple streams... continuously. This unit—as well as the Model 220, capable of analyzing up to eight components—is available in air-purgeable or explosion-proof housings.

Continuous gas chromatography is the quickest way to get an accurate picture of your process composition... an assurance of optimum production. This technique allows you to maintain correct material balance, and instantly warns you of production upsets. Eliminate the costly dangers of delayed analysis reports—use continuous 'round-the-clock chromatography for rapid, accurate stream analysis.

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For more information about Beckman Industrial Gas Chromatography, write for Bulletin P-11-26.

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GAS CHROMATOGRAPHS • INFRARED GAS ANALYZERS • INDUSTRIAL pH SYSTEMS • THERMAL CONDUCTIVITY ANALYZERS
ELECTROLYTIC HYGROMETERS • FLOW COLORIMETERS • LEAK DETECTORS • OXYGEN ANALYZERS • DENSITY BALANCES

New Equipment

Easy-To-Read Fuel Test. A new low-cost instrument for the determination of the smoke point of a wide range of hydrocarbon fuels has been announced by Central Scientific Company, chief manufacturing subsidiary of Cenco Corporation. The device is a smoke point lamp, equipped with a chimney calibrated in millimeters, so that the smoke point of a sample under test can be read off directly. The smoke point of a hydrocarbon is the maximum height of the flame in millimeters at which the fuel will burn without smoking. The Cenco smoke lamp, is delivered complete with 2 chimneys and six 6-in. wicks. *Central Scientific Company.*

Circle number (52) on reply card.

Discpak Swivel Joint. A new swivel joint, designed specifically for steam and hot gas service, has been placed on the market by the Chiksan Company. Named the Discpak, this swivel joint embodies a design which permits packing units to be replaced without removing the Discpak from the line. The Discpak has a maximum temperature rating of 600 F and a maximum pressure rating of 300 psi. It is currently available in sizes of ⅜, ½, ¾, and 1 in. *Chiksan Company.*

Circle number (53) on reply card.

Steam-Reactivated Dehydrators. A new line of steam-reactivated dehydrators for drying instrument air and process gas is announced by Selas Corporation of America. Available in 11 sizes, handling from 10 scfm to 1000 scfm (air at 70 F and 100 psig) in continuous operation with manual, semi-automatic or automatic cycling, the dehydrator design is the outgrowth of Selas' experience in designing and building custom-engineered units. *Selas Corporation of America.*

Circle number (54) on reply card.

Vari-Cap Pump. The new Granco Vari-Cap Pump has been announced by Granberg Corporation. Its name is derived from the fact that its capacity can be changed to suit the product being pumped by a simple dial setting. No slide rule calculations or gear changers are necessary. All that is required is a setting by dial to maintain the output capacity desired.

This metering pump can be ideally used for blending and processing operations, such as fuel oils, caustics, additives and various other chemical products. The speed of the pump can be adjusted to handle products of varying viscosities. The operation can be powered from standard capacity motors and the differential taken up in the pump's adjustment. The range of adjustment is from zero to 40 gpm, at 500 rpm. *Granberg Corporation.*

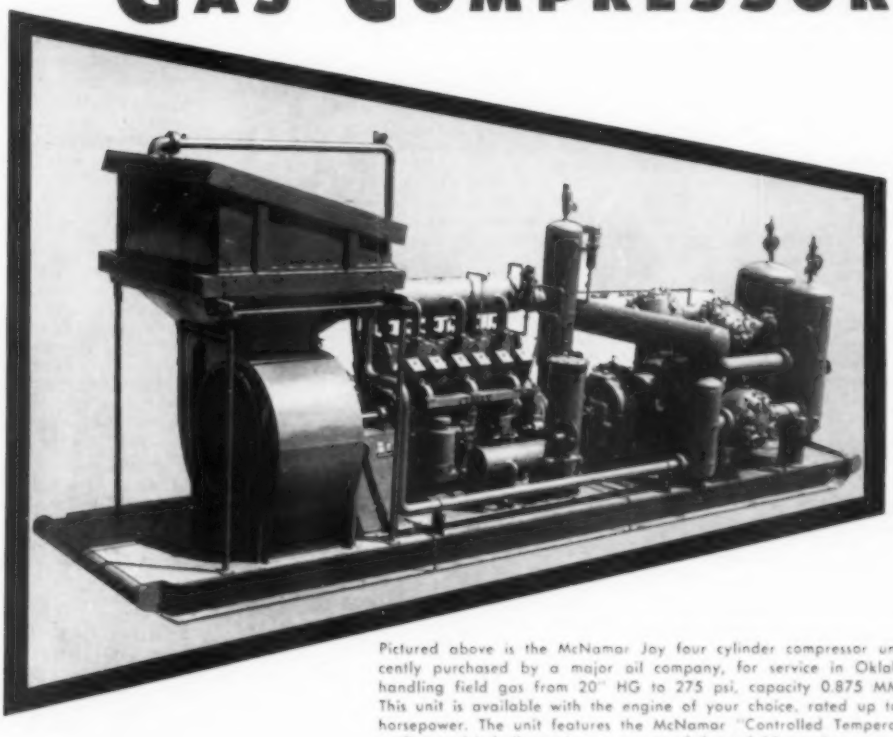
Circle number (55) on reply card.

X-Y Recorder. A new electronic dynamaster X-Y recorder has been announced by The Bristol Company. The strip-chart recorder will automatically plot a continuous curve showing the relationship of one measured variable to another.

The dynamaster records on a 12-in. strip chart, and is available in pen speeds of up to 0.4 sec for full scale traverse to follow the most rapidly changing variables. Standard accuracy is 0.25 percent. *The Bristol Company.*

Circle number (56) on reply card.

McNAMAR-JOY
GAS COMPRESSORS



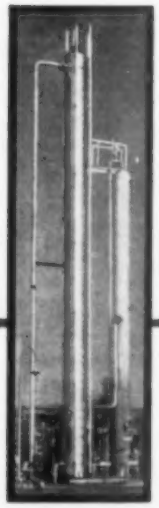
Pictured above is the McNamar Joy four cylinder compressor unit recently purchased by a major oil company, for service in Oklahoma, handling field gas from 20" HG to 275 psi, capacity 0.875 MMCFD. This unit is available with the engine of your choice, rated up to 400 horsepower. The unit features the McNamar "Controlled Temperature" cooling and is built to give you years of dependable service.

McNamar Joy-Gas Compressor units are available in one, two or four cylinder models. The four cylinder unit is rated up to 400 horsepower with one, two, three or four stages of compression, developing pressures up to 2,000 psi. The overall weight of this unit is 45,000 pounds.

Single cylinder, single stage units are rated to 100 horsepower. The two cylinder, single or two stage units are rated to 200 horsepower.

The McNamar-Joy unit is complete with rugged Joy compressor, gear reducer or belt drive, engine, cooling system, scrubbers, piping and safety controls mounted on a single structural steel skid.

The unit is extremely portable and can be moved on a tandem semi-trailer without disassembling. The arrangement of the equipment allows easy access to all parts for low maintenance costs.



McNamar Portable GASOLINE PLANT

The McNamar portable gasoline plant is designed for flexible application and automatic operation. Simplicity of design assures dependable operation and low maintenance costs.

The McNamar-Joy Compressor Unit is low in cost and is available on purchase, rental, or rental purchase option basis.

Call, write or wire McNamar Compressor Division for further information.

De-Sulphurization Plants Glycol and Solid Dessicant Units

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NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

High-Force Centrifuge. Details of the new Beckman Spinco Model K, a 51,000-times-gravity laboratory centrifuge, are given in a new publication identified as Form SBK-1. Featured in the literature are details on the newly developed, insulated, core-ventilated rotors which make it possible to operate a centrifuge up to speeds of 25,000 rpm in air without rotor overheating and without the resulting problems of thermal convection in the rotor. *Spinco Division, Beckman Instruments, Inc.*

Circle number (57) on reply card.

Unit-Line Pumps. Johnston Pump's new sheet on their unit-line pump briefly describes the applications of this construction to different installations. This modification eliminates the need for oil lubrication or packing boxes for these extended pump lengths (may be extended to 20 ft settings). *Johnston Pump Company.*

Circle number (58) on reply card.

Metal Alloy Handbook. A unique 35-page publication, Price Schedule No. 12, has been released by Techalloy Company, Inc. For purchasing agents it is an easy-to-use price schedule with simplified pricing. For design engineers it is a technical handbook of wire, rod and strip.

Price-wise, publication features enlarged versions of "Quik-Chek" charts which were originated by Techalloy. These schedules have basic prices and all extras listed on one page to save figuring time and to eliminate errors. *Techalloy Company.*

Circle number (59) on reply card.

Comparative Heat Exchanger Costs. New booklet, "Design and Cost Comparison of Heat Exchangers . . . Using Wolverine Trufin", is designed to assist engineers, estimators and designers. It gives a rapid analysis of the comparable costs between a plain condenser tube and a Trufin Type S/T shell and tube exchanger over the range of the more common applications. Companies using shell and tube exchangers will be able to quickly estimate where it should be used and the economies. *Wolverine Tube Division, Calumet & Hecla, Inc.*

Circle number (60) on reply card.

Practical Data System. New 8-page brochure describes a practical data system for the process industries. Detail is given on the economics of automatic data processing in the present day well-instrumentated plant. Described is the new Beckman Model 112 System which also justifies consideration of its use as a controller as well as a data processor. *Systems Division, Beckman Instruments, Inc.*

Circle number (61) on reply card.

Hose Handling Accessories. A new lightweight hose saddle permits quick and easy slinging of oil cargo hose and prevents kinking and damage. Constructed of specially reinforced fiberglas, the Boston saddle is a time and work saver for any application involving large diameter hose.

Another new hose handling accessory is Boston's non-sinkable hose dolly. This reinforced fiberglas dolly is designed to fit all sizes of heavy duty and lightweight oil cargo hose. *Boston Woven Hose & Rubber Company.*

Circle number (62) on reply card.

High-Speed, Centrifugal Pumps. New line of high-speed, high-head centrifugal pumps for general water service has been announced by Gardner-Denver Company. The Model BH pumps are available in 4 sizes — a 1 in. model with capacities to 150 gpm, and 1½ in. model with capacities to 220 gpm, a 2 in. model with capacities to 440 gpm and a 3 in. model with capacities to 520 gpm. *Gardner-Denver Company.*

Circle number (63) on reply card.

Gas Generators. A new brochure describing the line of gas generators manufactured by A. A. Straub Company has been announced. The 4-page, 2-color folder includes an interesting description of the 3 basic types of gas generators made by the company. *A. A. Straub Co., Inc.*

Circle number (64) on reply card.

Accumulators On Lift Trucks. Yale & Towne has published a bulletin describing the functions of an accumulator in the hydraulic system of an industrial lift truck. When trucks are used over rough terrain, these devices have been found to reduce shock impact to the load and lifting mechanism by as much as one-half. *Yale Materials Handling Division, The Yale & Towne Manufacturing Company.*

Circle number (65) on reply card.

Carbon Brush Performance. Getting the best performance out of carbon brushes is the theme of a new booklet, GEA-6688, published by the General Electric Company. The 8-page booklet contains question-and-answer interviews covering brush life, metal transfer, commutator threading, bar marking, and commutator adjustment. *General Electric Company.*

Circle number (66) on reply card.

"Special Loy" Guide. A new 8-page fully illustrated pamphlet (TIS 2836A) is available from Eutectic. New methods are discussed of low heat input welding, brazing and soldering that can sharply reduce the time duration of a metal-joining job. Sample problems covered in the guide include methods for welding crack sensitive and heat treatable steels, how to fill, seal and build-up heat sensitive cast iron alloys and directions to take the guess work out of aluminum and magnesium joining. *Eutectic Welding Alloys Corporation.*

Circle number (67) on reply card.

New Clamp and Fastener Catalog. Featured in this catalog is Bassick's new gearlock clamp line which uses a wormlock mechanism to provide air-and-moisture-tight seals in heavy containers with closure strengths up to 2000 lb. Also included in the new 16-page catalog are Bassick's lines of hook type clamps, loop type clamps, hinge type clamps, spring loaded clamps and special duty clamps. *Specialty Hardware Department, Bassick Company.*

Circle number (68) on reply card.

Safety Shut Off Valve. Bulletin 741 describes a mercury-actuated safety valve which gives the oil industry protection from gas pilot failure. Mechanically operated, it cannot be tied open. *The Partlow Corporation.*

Circle number (69) on reply card.

Ripple Tray. A complete description of the ripple tray patented by Stone & Webster Engineering for use in petroleum refining, chemical processing and distillery operation, is given in a recently issued brochure. The newly-developed perforated trays for distillation columns are manufactured from light gage sheet metal which is perforated and corrugated. *Stone & Webster Engineering Corporation.*

Circle number (70) on reply card.

Vapor Fractometers. A 24-page brochure describing the Model 154-C single-stage vapor fractometer and the Model 188 triple-stage vapor fractometer, new gas chromatography instruments has been published by the Perkin-Elmer Corporation.

The Model 154-C offers all the specialized features of the P-E 154 series, plus an expanded line of standard columns, precision electronic temperature regulation, reverse flushing feature and automatic recorder range control. The Model 188 triple-stage vapor fractometer makes possible the single run analysis of a sample containing a large number of components which boil over a wide range. *Perkin-Elmer Corporation.*

Circle number (71) on reply card.

Chemical Feeder Catalog. Manzel, a division of Houdaille Industries, Inc., has released a new catalog on its line of chemical feeders. The 36-page, file-size booklet is claimed to be the most complete catalog available on metering pumps.

Included in the catalog is a complete description of every class of pump, with details on construction, displacement and operating pressures, together with recommendations for use in handling specific chemicals, acids and other liquids. The catalog is illustrated with photographs, cut-away drawings and technical data. Handy volumetric conversion tables and a listing of pump components and accessories are also given. *Manzel.*

Circle number (72) on reply card.

New Line Of Etched Parts. Photo-forming of metal parts for a greater variety of industrial and commercial products is illustrated and described in Bulletin 90 published by Superior Tube Company. Photo-formed parts are the latest products in Superior's line.

Two processes—chemical etching and electrolytic etching—are described in the bulletin. *Photo-Forming Department, Superior Tube Company.*

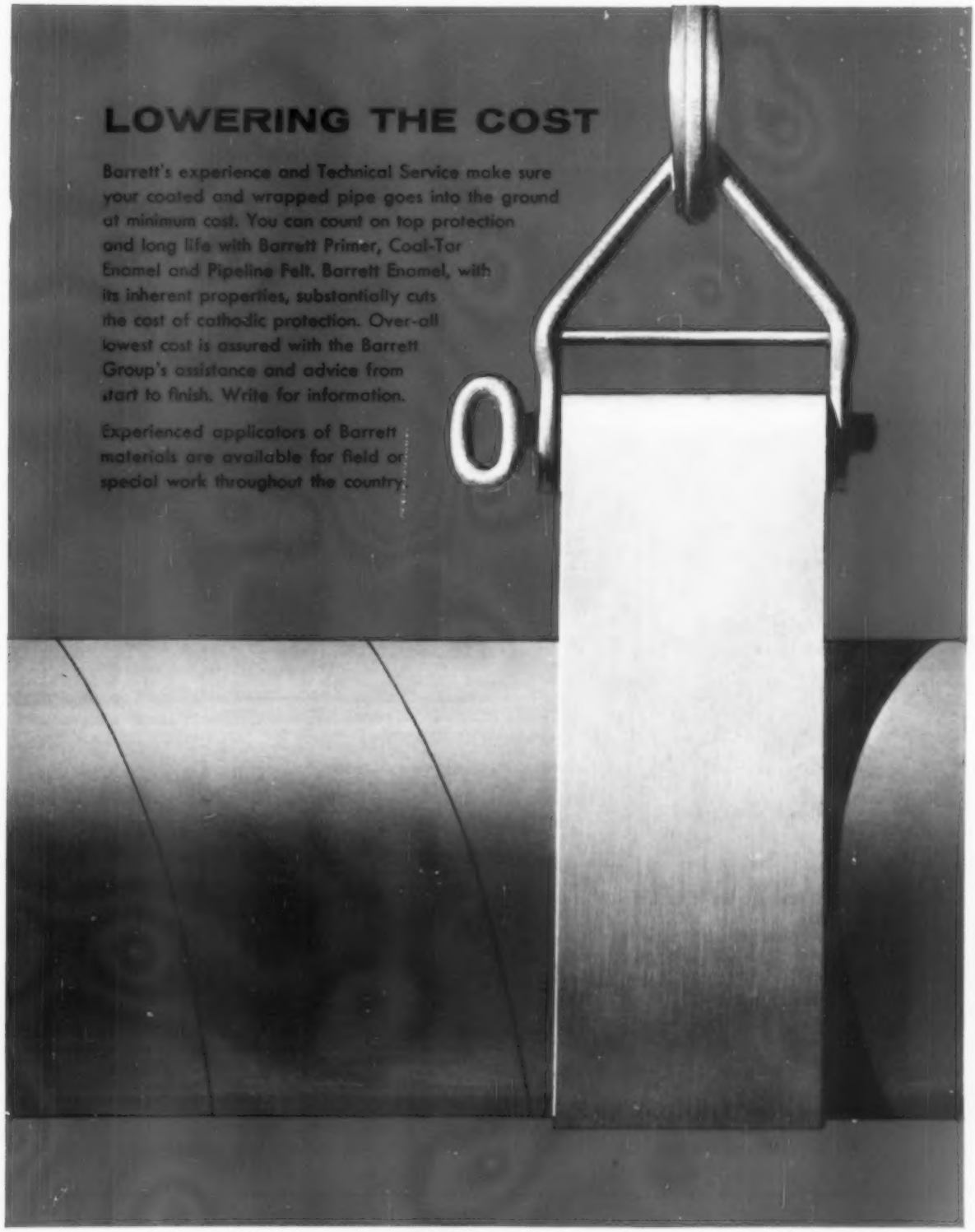
Circle number (73) on reply card.

Basic Safety Controls For Low Pressure Steam Boilers. A 24-page book has been published by McDonnell & Miller covering basic safety controls for all low pressure steam boilers. The new steam book tells the story in simple diagrams and even simpler explanation; wastes no words on product description; adheres to the why and how of all authoritative methods of providing maximum safety and automatic water level control for all low pressure steam boilers. *McDonnell & Miller, Inc.*

Circle number (74) on reply card.

Flexible Cushion Coupling. A new 12-page bulletin describes Para-flex, completely different flexible cushion coupling. Full page of general information explains how the coupling, by means of rubber tire element, accommodates angular misalignment, parallel misalignment and end float, singly or in any combination, besides cushioning shock loads and diminishing torsional vibration. *Dodge Manufacturing Corporation.*

Circle number (75) on reply card.



LOWERING THE COST

Barrett's experience and Technical Service make sure your coated and wrapped pipe goes into the ground at minimum cost. You can count on top protection and long life with Barrett Primer, Coal-Tar Enamel and Pipeline Felt. Barrett Enamel, with its inherent properties, substantially cuts the cost of cathodic protection. Over-all lowest cost is assured with the Barrett Group's assistance and advice from start to finish. Write for information.

Experienced applicators of Barrett materials are available for field or special work throughout the country.

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PROTECTIVE COATINGS

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Allied Chemical

OVER 100 YEARS OF EXPERIENCE

Let's get technical about WALWORTH LUBRICATED PLUG VALVES for pipeline service

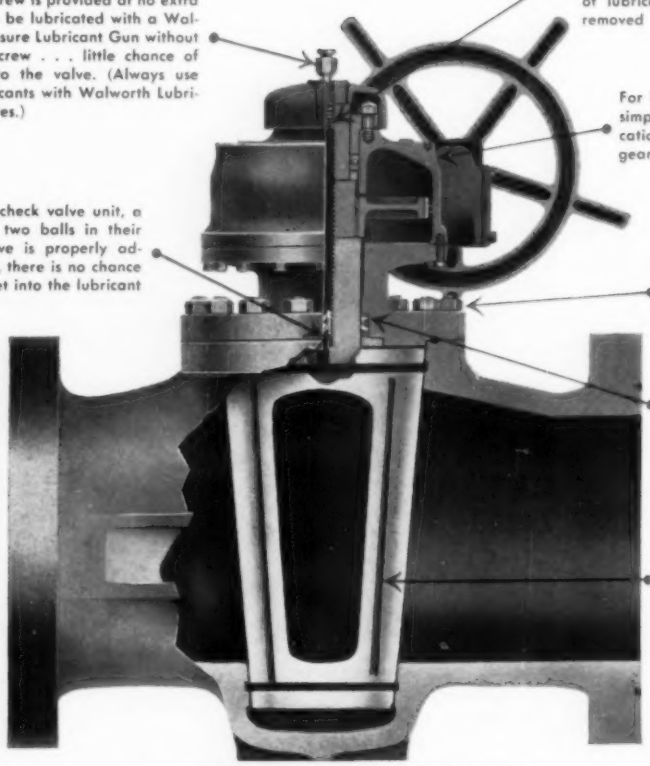
Combination button-head lubricant fitting and lubricant screw is provided at no extra cost. Valves can be lubricated with a Walworth High Pressure Lubricant Gun without removing the screw . . . little chance of grit getting into the valve. (Always use Walworth Lubricants with Walworth Lubricated Plug Valves.)

An added safety feature in the form of a groove cut part way up side of the lubricant-fitting screw allows the operator to observe any tendency of lubricant to blow out before the screw is removed entirely.

For buried pipelines — yoke design permits simple attachment of handwheel and lubrication extensions without modifying the gearcase.

In the stainless steel check valve unit, a transverse pin holds two balls in their seats. When the valve is properly adjusted and lubricated, there is no chance for line pressure to get into the lubricant system.

Standard bolt threads, rather than fine threads, mean easy replacement of nuts and bolts from local stocks.



Two overlapping Teflon packing rings form an effective seal against possible leakage without "grabbing" the plug shank. Low breakout torque . . . plug turns easier. Packing serves only as a seal and is not used to hold the plug in its seat.

Lubricant grooves completely frame the port openings and encircle the plug at the top and bottom assuring a tight seal against leaks. Bottom circumferential groove is separate from, but connected with, the lubricant well.

Other Walworth Lubricated Plug Valves include Single Gland and Regular Gland types. Sizes to 30 inches. Pressures to 5000 psi. and for vacuum service.

Cutaway of a 24-inch Walworth Lubricated Plug Valve

Without exception, a Walworth Ball Bearing Lubricated Plug Valve is easier to operate and maintain than any other type of rotary-action, sealed valve available today for pipeline service. Design features pointed out here show just a few advantages of Walworth Ball Bearing Lubricated Plug Valves.

Many pipeline companies throughout the world use Walworth valves for handling gas, crude, and finished products. Investigate the line of Walworth valves for your own needs. See your Walworth Distributor, or write for literature: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

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WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALOYCO ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION GROVE VALVE & REGULATOR CO. SW SOUTHWEST FABRICATING & WELDING CO., INC. MH M & H VALVE & FITTINGS CO. WALWORTH COMPANY OF CANADA, LTD.

Proposed or Planned Pipelines

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Act Oils Toronto, Ontario, Canada	350		Line from Peace River area in British Columbia, thru Pine Pass to Prince George, westward to Bella Coola terminus on Pacific Coast
Argentine Government (YPF) Buenos Aires, Argentina	640	12	Campo Duran fields to Rosario
Atlantic-Cities-Service-Continental-Gulf-Phillips-Texas-Sinclair	Approx. 385	26	Midland, Texas, area to Houston
Bolivian Gulf Oil Corp. La Paz, Bolivia	202	8, 10	Sicascia to Arica
Cape Pipe Line Company Philadelphia, Pennsylvania	200		Large diameter from Delaware Bay to Greater Philadelphia area refineries
Creole Petroleum Corp. Caracas, Venezuela	86	30	Temblador field to Caripito, Venezuela
Great Northern Railway Co. St. Paul, Minnesota	800		Williston Basin to St. Paul-Duluth-Superior, Wisconsin-Minnesota area
Iran Government	1000	38	Qum, Iran, to Iskenderun, Turkey
Iraq Petroleum Co. London, England	Approx. 600		Kirkuk field to Iskenderun, Turkey
Magnolia Pipe Line Company Dallas, Texas	131	12-20	Midland-Clyde-Corsicana, Texas, loops
Musgrove Petroleum Co. Wichita, Kansas	180		Hugoton field, Kansas, to Raymond, Kansas
North-West Oil Pipelines Company	210		Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Northwest Pipe Line Corporation Salt Lake City, Utah	350	8–10	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Oil Field Pipe Line, Inc. and Panhandle Eastern Pipe Line Co. Kansas City, Missouri	200	8, 12	Elkhart to Ellinwood, Kansas
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Southern Kansas Pipe Line Company	310	6, 10	10,000 bbl per day line from Greenwood pool, near Colorado line, thru Liberal to Arkansas City, Kansas
Trans-Border Line Company	110		Skagway, Alaska, to Whitehorse, Yukon Territory
17 American, English, French and Dutch companies	1500	38–40	Middle East producing areas to Mediterranean Coast in Turkey

PRODUCT LINES

Name of Company	Miles	Size	Location
American Pipe Line Co. New York, New York	1910	8–26	Beaumont, Texas to Newark, New Jersey
Buckeye Pipe Line Company New York, New York	70	8	Wayne to Durand, Michigan, common carrier
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Everglades Pipe Line Company Everglades, Florida	60	10	Pt. Everglades to Miami, Florida
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6–8	Edmonton, Alberta, to Fort William, Ontario
Laurel Pipe Line Company Pittsburgh, Pennsylvania	350	14–24	Philadelphia to Pittsburgh to Cleveland
Mene Grande Oil Co. Caracas, Venezuela	60	6	Anaco to Puerto La Cruz, Venezuela
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Ohio Oil Company Findlay, Ohio	250	12	Hartford, Illinois to Griffith, Indiana
Service-Continental-Sinclair-Phillips	550		Salt Lake City, Utah to Spokane, Washington
Underground Storage and Exploration, Inc.	393	6, 8, 12	Moundsville, West Virginia, to Newark, New Jersey, with laterals to Mauch Chunk, Marcus Hook, and Philadelphia
Union Oil Company of California Los Angeles, California	815		Shale oil plant, Rifle, Colorado to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U.S. Canadian border to Winnipeg

HERE'S THE NEW HD-21...

Designed and Built to Fit Today's Big-Tractor Jobs

NEW HD-21 IN ACTION with new 15-ft. angle-dozer; approximate total weight, 56,225 lb.

Now . . . major advances make the Allis-Chalmers HD-21 more productive than ever . . . capable of handling big-tractor jobs of every kind with the efficiency and dependability all pipeline contractors want and need.

New 225-net-hp turbo-engine

New weight—45,500 lbs (bare)

New power train and torque converter effectiveness and simplicity

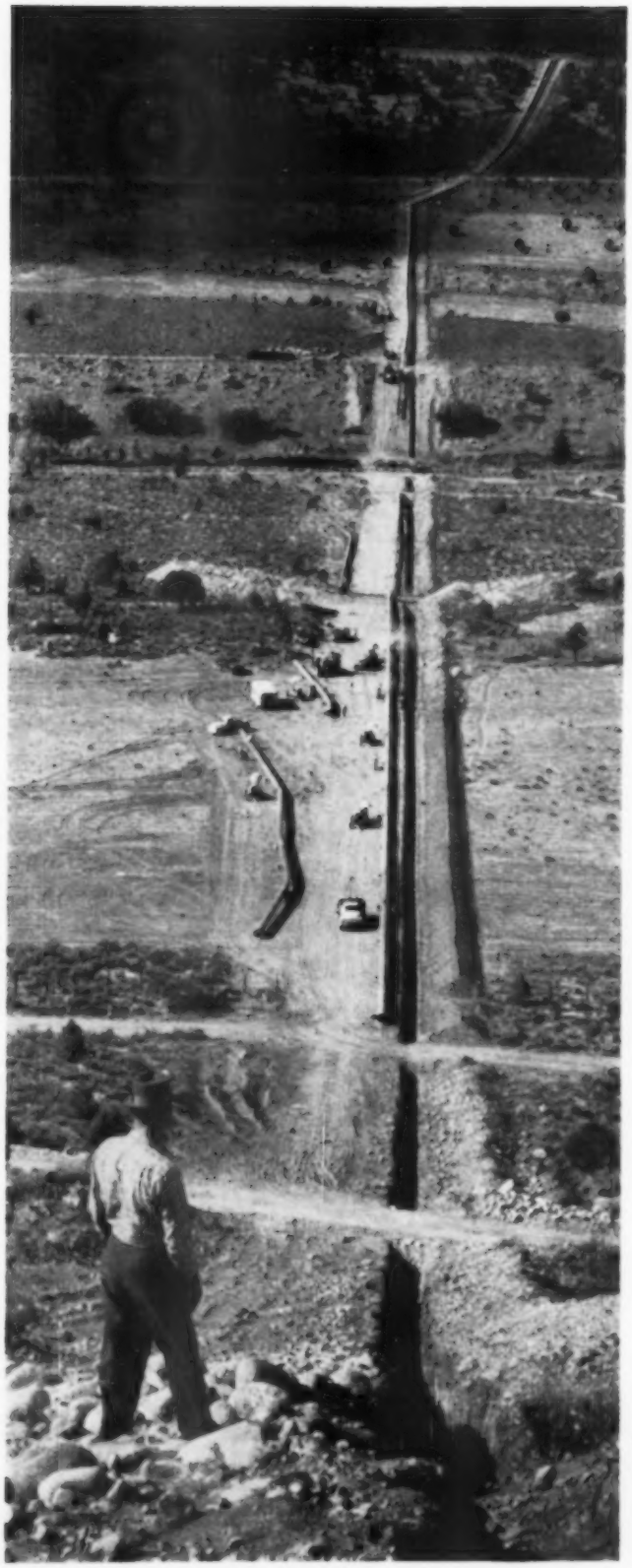
New longer track for matched traction, flotation

New operating ease and control with work-saving decelerator

New heavy-duty matched dozers, sideboom

Here's a big tractor you can depend on to help you bid with confidence in your cost estimates. Your Allis-Chalmers dealer will be glad to talk to you about the new "21" . . . and to prove its value in a working demonstration on your job. Allis-Chalmers, Construction Machinery Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS *Engineering in Action*



CROSS COUNTRY CHAMP!

When the going gets rough and the miles start stretching out . . . that's when you appreciate the quality of Kaiser Steel line pipe.

Here's pipe that's made for rigorous conditions. *Precision* pipe that in every length assures the kind of true uniformity that makes handling easier, installation quicker.

Kaiser Steel's fully-integrated western operation assures quality control—permitting no less than 52 tests and inspections from mine to market.

Result: in diameter, concentricity, ductility, strength . . . wherever accuracy and performance count most . . . you can count on pipe of Kaiser Steel to pay off for you in the field.

Kaiser Steel

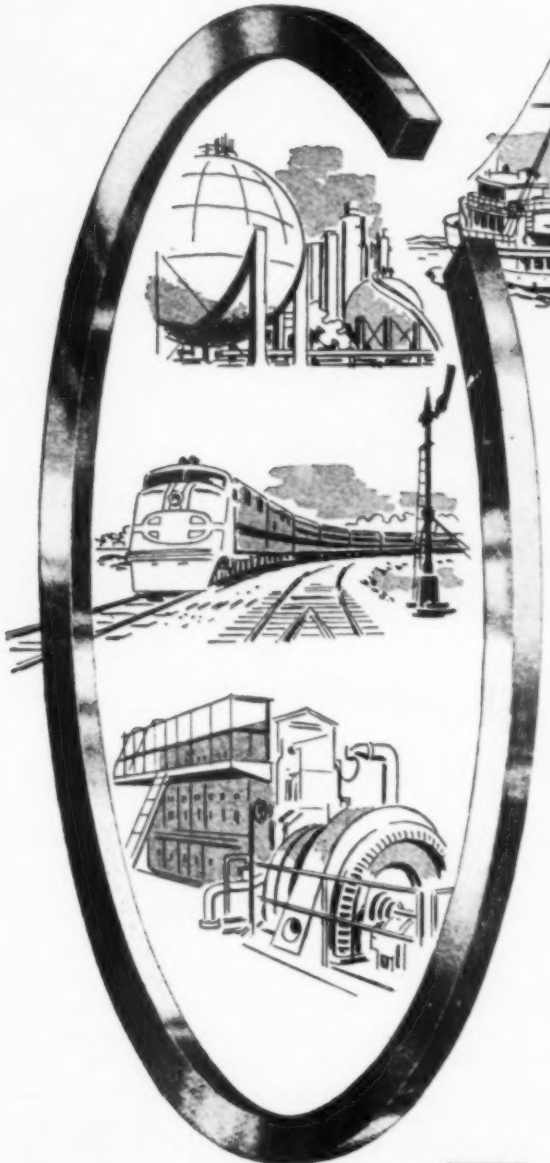
Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes • semi-finished steels • pig iron • ingot molds • coke by products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe • reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • **Los Angeles** • **Oakland** • **Seattle** • **Portland** • **Phoenix** • **Denver** • **Tulsa** • **New York**

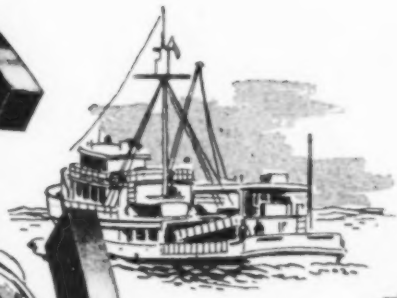
GAS LINES

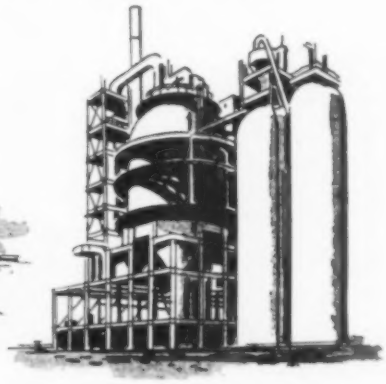
Name of Company	Miles	Size	Location
Alberta Gas Trunkline Company, Ltd. Calgary, Alberta, Canada	449	6–34	Extensions to connect various fields
Andes Pipeline Corporation	500	12	Villamontes, Bolivia to Antofagasta, Chili
Argentine Government (YPF) Buenos Aires, Argentina	815		Campo Duran fields to Buenos Aires
Arkansas Louisiana Gas Company Shreveport, Louisiana	300		Main and gathering lines Louisiana-Texas Gulf Coast
Cities Service Gas Company Oklahoma City, Oklahoma	117	12–30	Replacements in Kansas
Coastal Transmission Corporation	574	22–26	McAllen, Texas to Baton Rouge, Louisiana
Dallas, Texas	414	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company Colorado Springs, Colorado	917	4–34	New lines, loops, replacements in Texas, Colorado, Nebraska, New Mexico, Kansas, Oklahoma
Cuban Gas Transmission Company (Edwin Pawley) Los Angeles, California	1000		Mexico to Florida via Cuba
Eastern Shore Natural Gas Company Salisbury, Maryland	124	6, 8	Transmission line and facilities in Delaware and Maryland
Edison Securities Company Los Angeles, California	130		San Joaquin Valley to Los Angeles
El Paso Natural Gas Company El Paso, Texas	599	6–30	New lines and loops, New Mexico and Arizona
Houston Texas Gas & Oil Company	942.6	12–30	Baton Rouge, Louisiana to Miami, Florida
Houston, Texas	682		Laterals to serve Florida distributors and industrial users
Iron Ranges Natural Gas Co. St. Paul, Minnesota	115		In Mesabi Iron Range area
Michigan Wisconsin Pipe Line Company Detroit, Michigan	638	4–24	Laterals and loops in Wisconsin, Michigan, Missouri, Illinois, Indiana
Midwestern Gas Transmission Company Houston, Texas	2067	3–24	Main line from U.S. Canadian border near Emerson, Manitoba—Noyes Minnesota, to Portland, Tennessee Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Natural Gas Pipeline Company of America	416	36	Loop from Beatrice, Nebraska to Joliet, Illinois
Chicago, Illinois	337	30	Loop from Fritch, Texas to Beatrice, Nebraska
Niagara Mohawk Power Corp. Syracuse, New York	196	2–16	Central, eastern, and northern New York
North Carolina Natural Gas Corp. Houston, Texas	625	2–16	Intrastate line in North Carolina
Northern Natural Gas Company Omaha, Nebraska	1569	2–30	New lines and loops, Minnesota, Wisconsin, Alberta, Texas, Oklahoma, Kansas, Nebraska, Iowa
Northern Plains Natural Gas Company **(subsidiary of Northern Natural Gas Company)** Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Offshore Gathering Company Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric Company San Francisco, California	1300	36	Alberta, Canada, gas fields to Antioch, California
Permian Basin Pipeline Company Omaha, Nebraska	83	16	Interconnection from proposed Pioneer's gathering system to Permian's facilities at Spraberry, Texas
	28.8	10	From Crane and Pecos counties, Texas to McCamey, Texas
Petroleos Mexicanos Mexico City, Mexico	130	22	Reynosa to Monterrey
Piedmont Gas Co. Hickory, North Carolina	78	2-8	In Gaston, Lincoln, Catawba, Caldwell, and Burke counties, N. Carolina
Pioneer Natural Gas Company Amarillo, Texas	116	6–16	New and replacement lines, Texas
Southern California Gas Co.	83	34	From Coles Levee to Newhall
Southern Counties Gas Co. Los Angeles, California			
Southern Natural Gas Company Birmingham, Alabama	371	4–20	Various lines in Louisiana and offshore
Tennessee Gas Transmission Company	556	30	South of New Orleans to Portland, Tennessee
Houston, Texas	76	24	Coudersport, Pennsylvania to Hamburg, New York
	163	30	Loop from Portland, Tennessee and Winchester, Kentucky to Lancaster and Morehead, Kentucky
	39	26	Loop from Catlettsburg, Kentucky to Broad Run, West Virginia
	12	26	Loop south of Mercer, Pennsylvania
	50	26	Loop from Morehead, Kentucky to Catlettsburg, Kentucky
Texas Eastern Penn-Jersey Corporation Shreveport, Louisiana	65	30	Loop from Delmont, Pennsylvania, to Lambertville, New Jersey
Texas Eastern Transmission Corporation	105	30	Loop from Vidor, Texas to Kosciusko, Mississippi
Shreveport, Louisiana	140	30	Loop from Kosciusko, Mississippi, to Uniontown, Pennsylvania
	22	14	New line, Rayne 30-in. line
Trans-Canada Pipe Lines, Ltd.	492	30	New line from Kapuskasing, Ontario, to Sheridan, Ontario, Canada
Calgary, Alberta, Canada	48	24	New line from Winnipeg, Manitoba to Emerson, Manitoba, Canada
Transcontinental Gas Pipe Line Corporation Houston, Texas	375	3–36	Main line loops, laterals, extensions to system
Trans-Western Pipe Line Company Los Angeles, California	775		Four Corner area to point in California

American Hammered Piston Rings...

field-tested money savers!







Why not specify piston rings that have *proved* themselves? Koppers rings have been saving money and cutting costs for years—throughout the oil and gas industry, the marine industry, on major railroads, all over the chemical field, throughout the aircraft business, in municipal and industrial power plants everywhere—wherever you find gas, Diesel or steam engines, pumps, compressors, forging hammers—*wherever piston rings are needed!*

They're built to take it . . . designed to cut downtime and maintain high compression . . . give longer, more satisfactory service . . . save you money on fuel and lubricating oil . . . *and that's exactly what they do.* And Koppers rings are available in all types, all sizes—from ½" to 10' diameter—specifically designed for the job they will do in the field where they will be used.

Always specify American Hammered Piston Rings. Benefit from over 100 years of experience in metal products. Use Koppers' complete engineering and metallurgical staff. Get skilled analysis of your specific problem, and prompt assistance. For 16 page Piston Ring booklet write to: KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.*, 1711 Hamburg Street, Baltimore 3, Maryland.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus.
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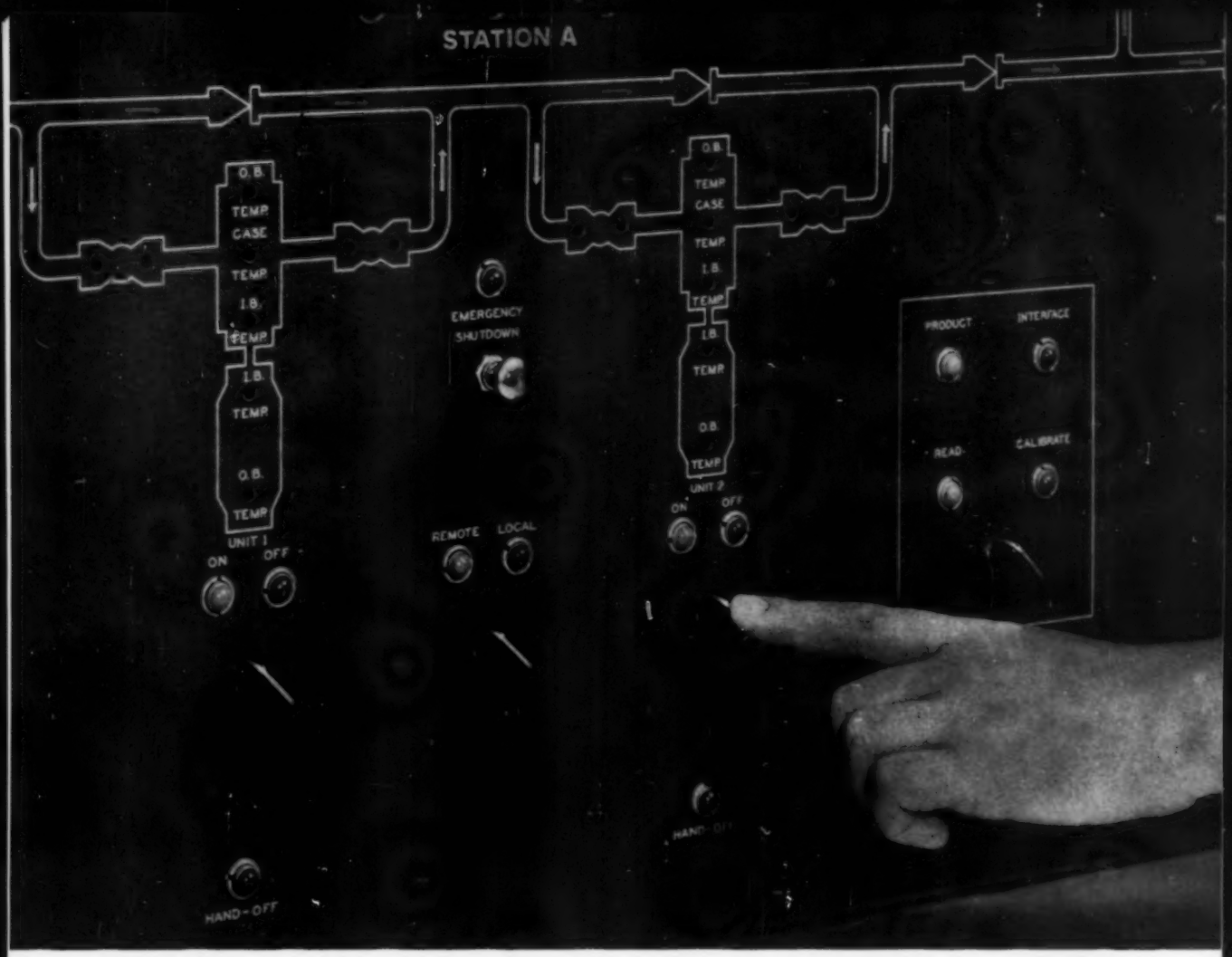

How to push a million gallons of oil from Texas to Chicago—*with one finger!*

A DISPATCHER, sitting at a control console in a central dispatching office, pushes a button—and Centralized Transport Control by Union Switch & Signal does the rest. Hundreds of miles away, a remotely controlled pump hums into action, giving the flowing oil the boost it needs. This is but one of many pumps, located in stations along the entire length of the pipeline, which are all controlled from the console.

On the control console, lighted diagrams tell the dispatcher exactly what is taking place at each pumping station along the line—which pumps are on the line, which valves are open. He can also obtain the temperature and pressures of the moving oil.

The dispatcher receives up-to-the-minute information constantly and automatically. He knows at all times what is happening throughout the entire system. He has fingertip control of all the pumps and valves that enable him to deliver oil at its destination in the most efficient and economical manner.

In the field of push-button science, Union Switch & Signal's record of achievement has been outstanding. In addition to control and communications equipment for pipelines, railways, subways, steel mills, and the mining industry, we have also designed and constructed electronic flight simulators, missile launchers, and air traffic control equipment.

We would welcome the opportunity to put our engineering knowledge and complete manufacturing facilities to work for you.

GENERAL APPARATUS SALES

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18, PENNSYLVANIA

Write for this new Pipeline Gate Valve Bulletin

Prepared for quick easy reference, this compact, complete and colorful new booklet is designed to simplify the engineering and management problems of pipeline gate valve placement, selection and specification. Write, wire or phone for your copy — or ask your nearest Grove representative.

packed with...

VALUABLE INFORMATION on valve design, testing and operation

COLORFUL ILLUSTRATIONS of valve types, construction and features

CHARTS AND GRAPHS to aid in venturi type valve applications

DIMENSIONAL TABLES covering 6" to 36" valves in ASA Series 150 to 600, WOG

MATERIAL SPECIFICATIONS for the exclusive Grove Seal-O-Ring Fabricated Steel Gate Valves

703

GROVE SEAL-"O"-RING Gate Valves

SUBSIDIARY OF WALWORTH

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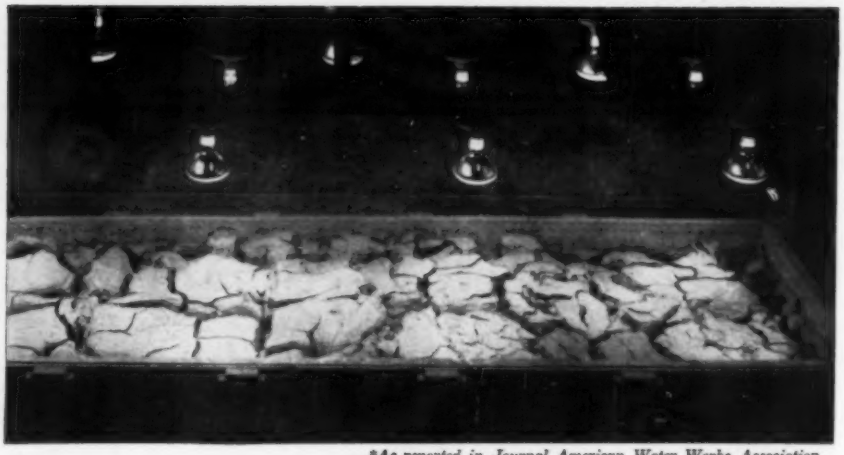
What happens to pipe wrap underground?

Here's what a federal agency found out*...

Many wrap and enamel combinations were imbedded in a test tank filled with bentonite clay slurry. Extreme soil stresses were imposed on these samples by alternate wetting and drying cycles. Resistance to backfill puncture was also checked after each cycle. Holiday-detection tests showed that the glass fiber and coal-tar combination stood up through the full 25 cycles of the test.



**As reported in Journal American Water Works Association, Vol. 48, Feb., 1956. Photo courtesy U.S. Bureau Of Reclamation.*

These impartial tests show why BLUE FLAG gives you complete pipeline protection

It was conclusively demonstrated that glass fiber mat like Blue Flag, with coal-tar enamel, provides effective protection against *both* soil-stress and backfill-puncture action. (See picture caption above for actual test conditions.)

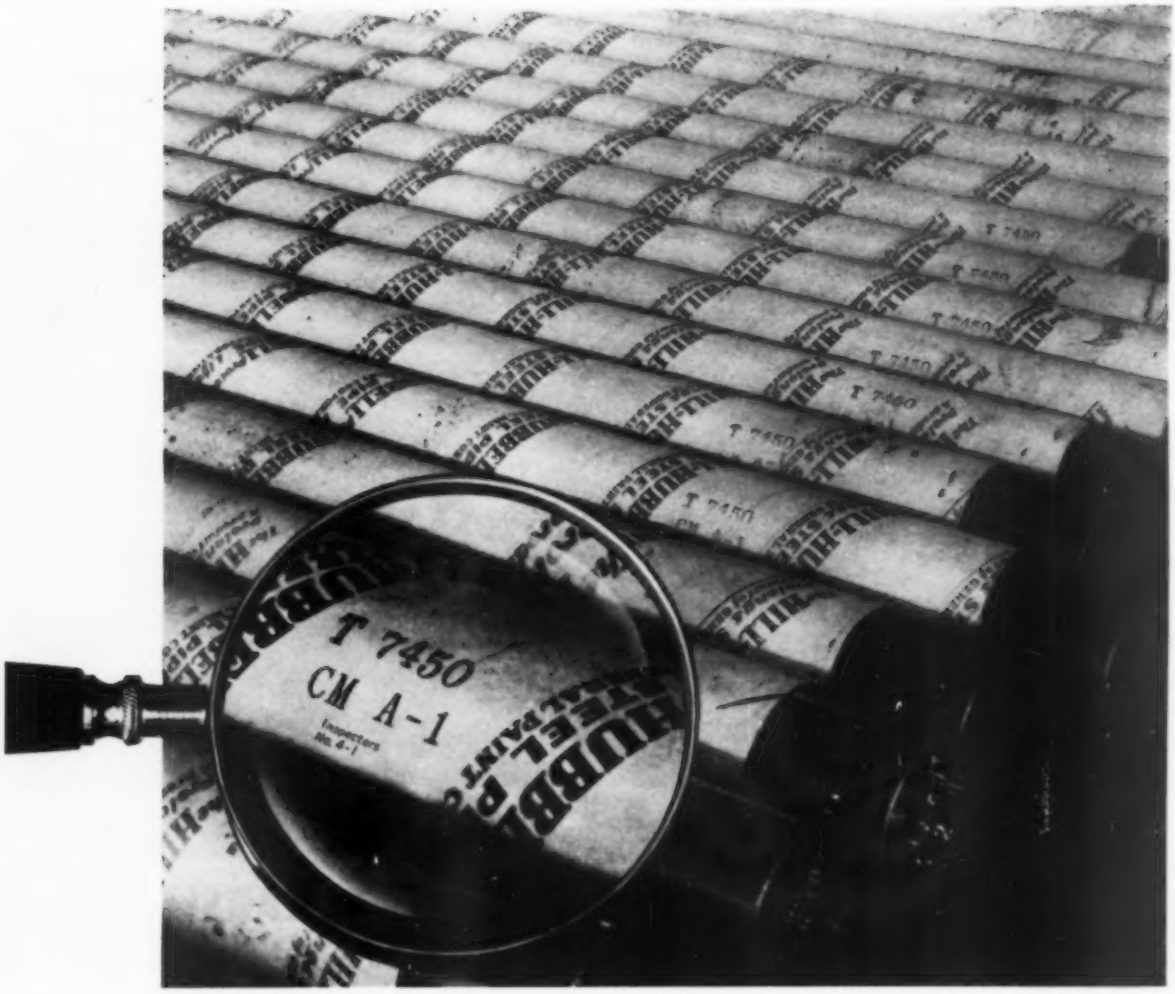
This is the kind of protection you need for maximum service life. Yet it's yours for only ½ of 1% of initial pipeline cost when you use L·O·F Glass Fibers' Blue Flag.

No wonder glass fiber reinforcement like Blue Flag Pipe Wrap is preferred. It strengthens enamel . . . assures coating essentially free of holidays. And, Blue Flag helps speed application—its high tensile strength virtually eliminates breakage in the wrapping operation.

Yard-wrapped, or applied over-the-ditch, Blue Flag can be the answer to your pipeline protection problems. It's available from conveniently located distributor warehouses. For the address of the one nearest you, or for technical information, write: *L·O·F Glass Fibers Company, Dept. 72-117, 1810 Madison Avenue, Toledo 1, Ohio.*

L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY • TOLEDO 1, OHIO



What? Autograph a piece of pipe?

Yes! The numbers stamped on Hill-Hubbell pipe wrapping are the job number, specification and signature of the man who inspected that pipe. When a Hill-Hubbell inspector signs a pipe he identifies the job and gives you his personal guarantee that the pipe is protected perfectly... permanently... to the ordered specifications.

Hill-Hubbell inspectors use modern electronic testing equipment to check every square inch of every pipe before it leaves the factory. In the field the stamp identifies the pipe as to job and specification. Hill-Hubbell inspectors have autographed pipe for 25 years... another "Quality-Control" first, pioneered by Hill-Hubbell.

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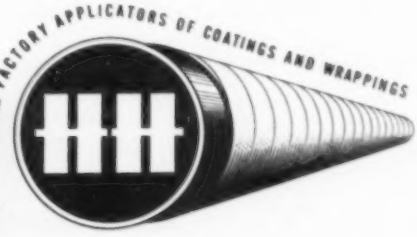

Natural Gas Pipeline Company of America Finds GAS LINE LIKE NEW AFTER 27 YEARS!

Bitumastic coal-tar enameled pipe to be re-used

In relocating its line to make way for a new highway near Truro, Iowa, the Natural Gas Pipeline Company of America removed some 900 feet of Bitumastic® enameled pipe laid in 1930. According to Mr. D. C. Allen, District Superintendent, this 24-inch seamless steel tubing is in such good condition that it will be reconditioned and used again as new pipe.

Applied by the rolling and "granny-rag" method in 1930, the Bitumastic XXH Enamel on this line was in excellent condition. The asbestos-felt overwrap, originally applied loose, was torn from soil stresses, but the Bitumastic enamel coating showed no serious disbonding or deterioration. At the time of relocation, the section had been under cathodic protection for two years. Natural Gas Pipeline Company of America records show no corrosion leaks on this section during the entire 27-year period underground.

Case histories such as this from prominent pipeline companies prove the unmatched protective ability of coal-tar enamel. In these days of rising material costs, you can't afford to gamble your entire pipeline investment on a less effective coating.

Your Koppers representative will be glad to give you full information on the superior protection of Bitumastic coal-tar enamels. Koppers District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward (Birmingham), Alabama.

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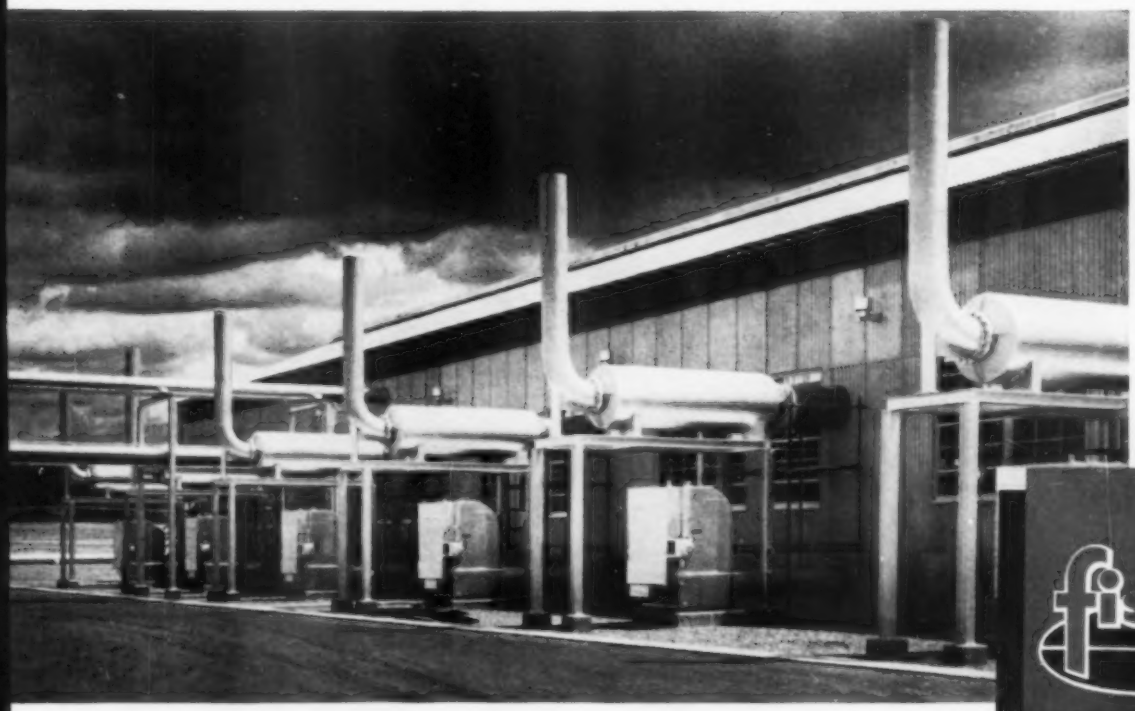
why this key compressor station works dependably despite these

temperature extremes



Compressor Station One is the key supply installation on the sprawling Pacific Northwest Pipeline system. Located at 6000 feet elevation near Ignacio, Colorado, the facilities boost pressure of nearly 300-million cubic feet of gas per day from the San Juan Basin gathering system. This station feeds a nearby gasoline plant before starting the gas on the long haul to the Pacific Northwest market.

In such a key spot, dependability is essential. Fish engineers carefully reviewed possible causes of trouble long before thoughts went into plans.

Extreme temperature fluctuations—from plus 100 degrees F. to minus 20 degrees F.—posed unusual problems. Under these conditions, reliable temperature control was difficult to achieve.

To be sure of providing efficient jacket water and lube oil temperatures under all extremes of ambient temperature and load, Fish designers elected to use unitized systems. Under this system, each engine has its own atmospheric cooler to take care of jacket water and lube oil cooling loads. A system of temperature control instruments was installed to provide very close control under all operating conditions. As designed, this remote station demonstrates extreme flexibility with reliability.

This is but one example of the type of advanced engineering you get from Fish. In addition, the same quality service prevails from feasibility study to project completion. If you are contemplating new or expanded facilities in oil, gas or chemicals, consult with Fish.

the fish companies

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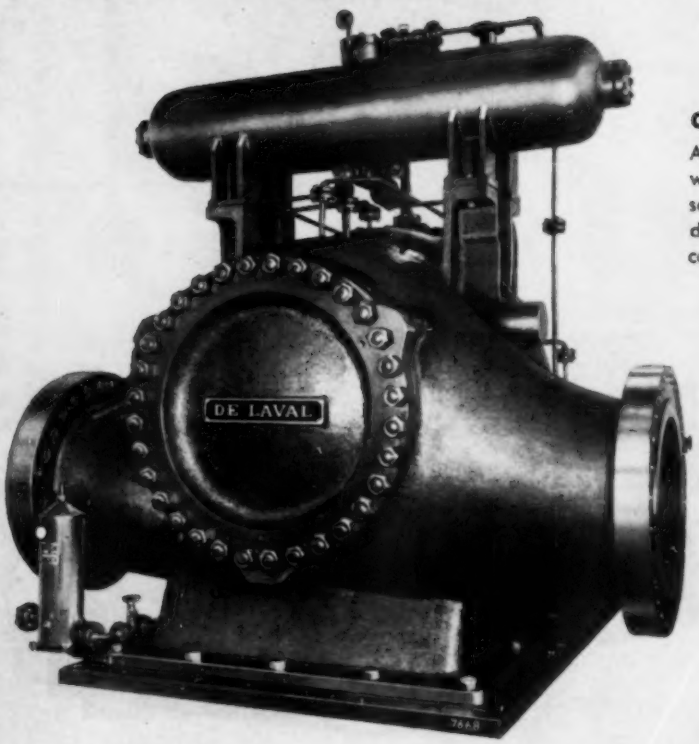
FISH SERVICE CORPORATION

DE LAVAL CENTRIFUGAL PIPELINE COMPRESSORS

come in two "packages" for easy installation



COMPRESSOR

A De Laval compressor with its emergency seal tank mounted directly on the compressor.

CONSOLE

The console contains the filters, motor-driven pumps, coolers, pressure switches, gauges and other accessories. It eliminates complicated piping on the packaged compressor . . . also serves as a protective cover for the equipment it houses.

Bulletin 503 gives data on De Laval centrifugal pipeline compressors. Write for your copy.

Designed in two packages, rugged De Laval centrifugal compressors offer many important engineering features. Among these are • high pressure contact shaft seal which eliminates gas leakage • heavy and rigid construction throughout • high load carrying capacity. The compressor and console arrangement makes De Laval centrifugal compressors easy to install—only simple low-cost foundations are required. De Laval units, totaling more than 280,000 horsepower, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
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ANOTHER LINK IN A MILLION-MILE CHAIN

This 30-foot section of pipe has been coated, wrapped, and is ready for service. It will take its place in the vast underground pipeline network that moves a greater volume than do trucks, railroads, ships and planes, combined.

It will become part of a great subterranean system that is vital to America's everyday living.

Let the facts speak for themselves. The gas industry alone handles over 10,000,000,000,000 cubic feet daily through more than half a million miles of transmission and distribution pipelines. A 185,000-mile pipeline system moves liquid petroleum products across the continent. In addition, there are many thousands of separate pipeline systems used to transport steam for power and heating —and to deliver water through municipal piping.

But there are problems—and one of the most important of these is corrosion. Pipeline companies and utilities must protect their metal pipe against the many corrosive elements that exist underground.

That's where Dearborn comes in. Dearborn's complete line of NO-OX-ID Coatings and NO-OX-IDized Wrappers provide both chemical and mechanical protection against moisture penetration and soil action—protection that lasts for decades—under ground or under water. That's why leading pipeline companies and utilities everywhere look to Dearborn for long-term protection against corrosion leaks and deterioration.

We will gladly consult with your engineers on the best NO-OX-ID Coating and Wrapper Combination for your next pipeline job.

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ON YOUR NEXT PIPELINE JOB

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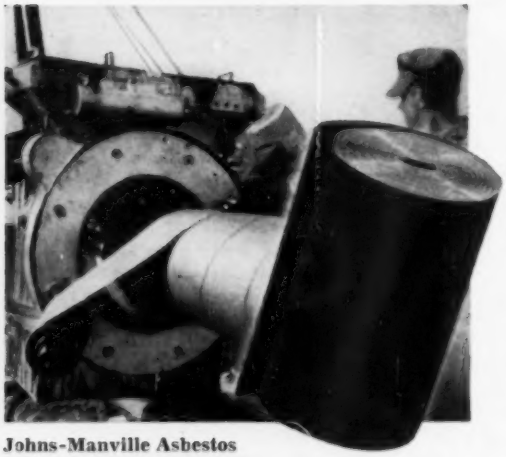
Like the "dillo's" tough shell that shields him so well...

Johns-Manville Asbestos Wrap shields oil and gas pipeline coatings



Johns-Manville Asbestos Felt is available in 3 types for field application or mill wrapping:

#15 Asbestos Felt—the high-strength, uniform asbestos wrap that has given superior protection to pipe coatings for more than 30 years—under the most severe soil conditions.

#15 Transhield—heavyweight asbestos felt with parallel glass reinforcement for high tear strength.

#8 Transhield—standard-weight asbestos felt with parallel glass reinforcement—for low-cost protection against average soil conditions.

J-M Asbestos Wrap provides the strong protection a strong coating deserves and needs. It offers the most effective single protection against damage—prolongs the working life of the pipeline coating. Here's why:

Asbestos is an ageless mineral . . . the fibres are strong and tough—cannot rot or decay. As used in J-M Wraps, the asbestos fibres are felted, then impregnated with a cold tar or asphalt saturant to form literally a flexible covering of stone. Like the "dillo's" tough shell that shields him so well—the enduring, "stonelike" J-M Asbestos Wrap shields pipeline enamels from earth loads, soil stress, and other forces that weaken coatings and permit corrosion of the pipeline.

Invite one of our engineers to show you the results of the three-year, extensive test program on "Pipe Line Coatings and Wrappers." Write to Johns-Manville, Pipe Division, 22 East 40th Street, New York 16, N. Y.

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Johns-Manville PRODUCTS FOR PIPELINE PROTECTION

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...EVEN WITHOUT STANDBY... WITH RCA MICROWAVE

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The original installation with short-haul leg circuits was used for voice channels and telemetering. Because of its reliability, additional channels were added, and RCA Equipment was chosen for the second installation.

Routes of El Paso Natural Gas Co.'s pipeline microwave systems in mountainous regions of Texas and New Mexico, and (below) microwave antennas on mountain.

RCA MICROWAVE assures the most advanced engineering features. Provision for the addition of future channels makes it the least expensive form of communication per channel mile. Equipment utilizes easy-to-service familiar circuits and conventional tubes. Single side-band suppressed carrier frequency division multiplexing is used exclusively to meet high standards of dependability. Frequency is controlled only from the terminals through the entire system. Furthermore, RCA provides the nation-wide services of the RCA Service Company to keep entire system operating at its peak.

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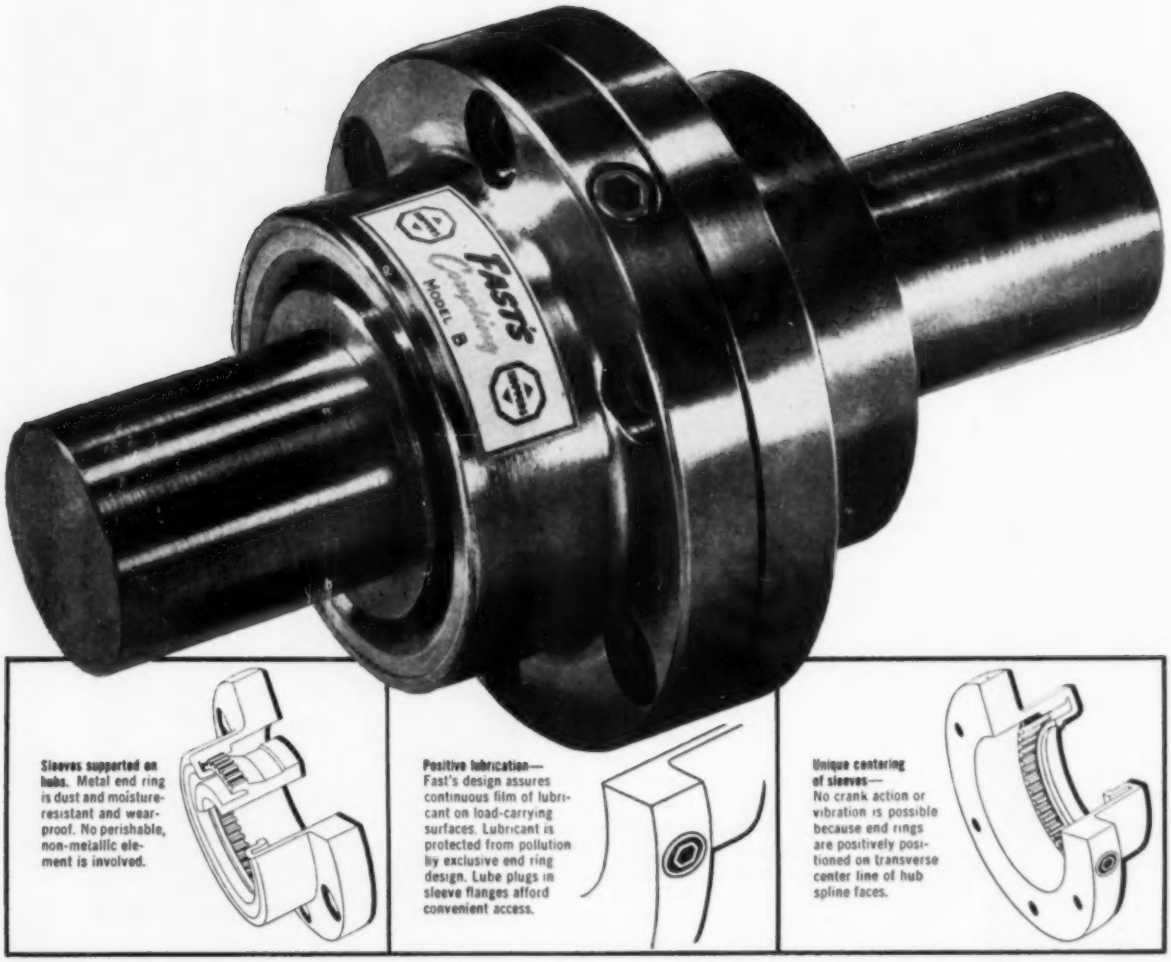
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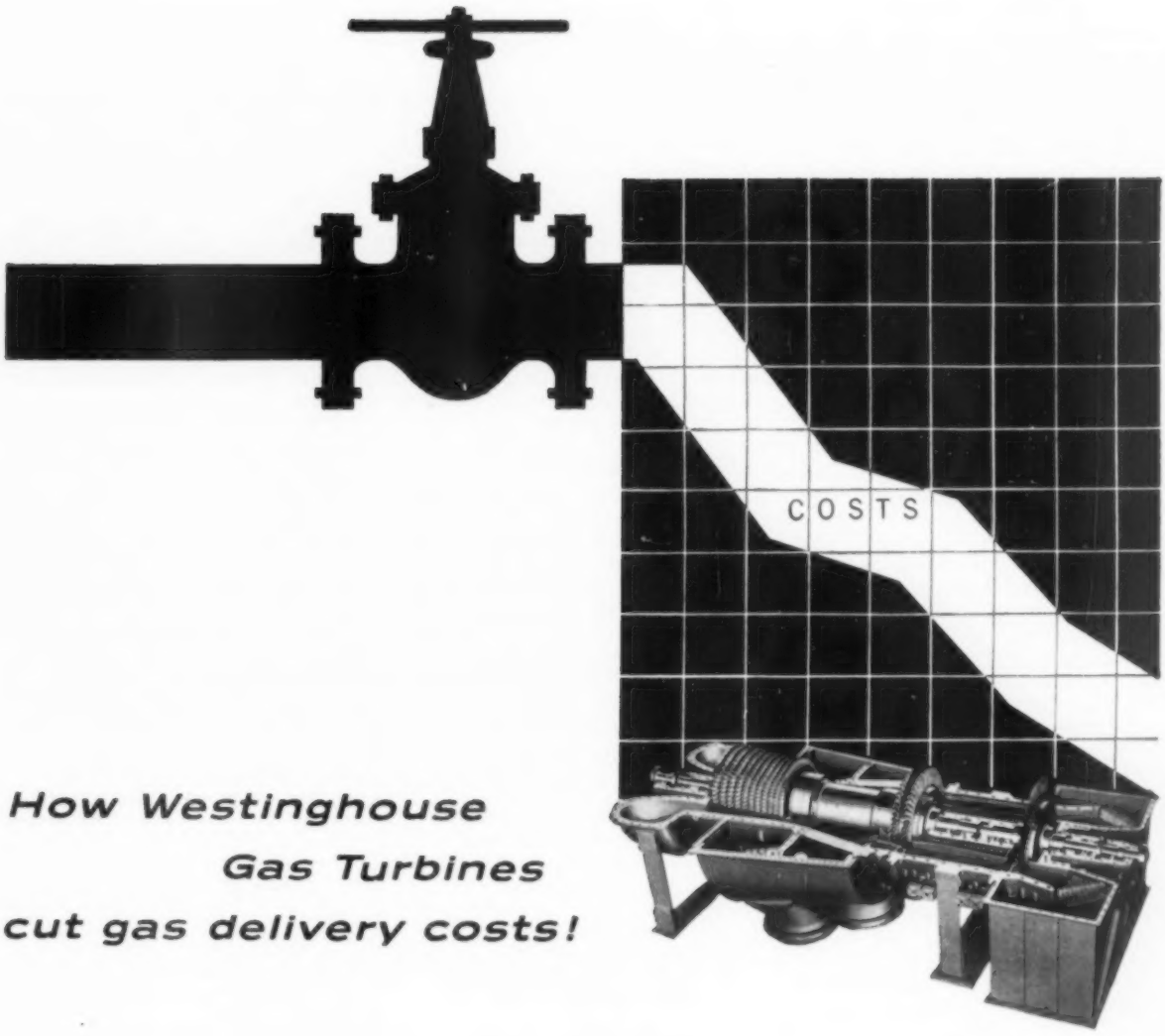

How Westinghouse Gas Turbines cut gas delivery costs!

EACH MONTH, MORE WESTINGHOUSE gas turbines are being installed for gas transmission. These orders indicate it's time to take another look at the savings offered by the modern Westinghouse gas turbine for pipeline pumping! Here's what you get:

Extra hp during cold weather—Up to 25% more horsepower . . . when you need it most!

Lower initial cost—based on unit horsepower, not considering the extra 25% during cold weather. And, usually, no reduction gear is needed.

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Venezuela

—More Pipelines in the Offing

Frank H. Love
Editor

VENEZUELA has been an important part of the world oil producing picture for many years, and the growth of pipelines in the country has kept pace with this development. It begins to look, however, as though the really big boom is in the offing. The brighter outlook for Venezuela is due to the fact that in 1956 new concessions were sold by the government, the first since 1945. For these concessions oil companies paid some three-quarters of a billion dollars in cash bonuses.

Discovery of oil in new areas seems inevitable and this means a stepping up of pipeline construction to move the crude to refineries within the country and to ports for shipment by tanker.

Details on the various company systems are given in succeeding paragraphs, and on following pages will be found special articles about certain operating and construction phases of some of these companies.

Creole Petroleum Corporation

Creole's trunk line system is among the most extensive in Venezuela. In operation are 485.4 miles of crude oil lines varying in diameter from 8 in. to 34 in., and an 11-mile, 8-in. refined products line. These figures do not take into consideration some 1200 miles of "flow lines" connecting wells in Lake Maracaibo to flow stations and the flow stations to lake shore, as they are considered a part of production facilities.

Pumping stations employ reciprocating and centrifugal pumps, and electric motors, gas-diesel engines, and gas engines to move the oil.

Creole also is planning a 92-mile, 30-in. line from Temblador to its refinery at Caripito. Initial capacity will be 48,000 bbl of high-viscosity crude. Both the main pump station at Temblador and the remotely operated booster station will be equipped with electric motors driving rotary pumps.

Now under construction is a 9.1-mile, 26-in. line between Ulé and La Salina, which will have a daily capacity of 400,000 bbl.

See Table 1 for complete statistics on Creole's operations.

Mene Grande System

The major part of Mene Grande Oil Company's pipeline operations is in Eastern Venezuela, where the company has 313 miles of 16, 26, and 30-in. lines taking crude oil from some 47 producing fields. The geographic designations of the areas in which these fields are located are Greater Anaco, Greater Oficina, Greater Urica, and Greater Santa Barbara.

Projected are a 76-mile, 30-in. crude oil line between Oficina and Puerto La Cruz, and a 61-mile, 6-in. LPG line from Anaco to Puerto La Cruz.

There are four pumping stations, at Oficina, Anaco, Travieso, and Puerto La Cruz. Pumping equipment in the first three are reciprocating pumps driven by diesel engines. The last has motor driven centrifugal pumps.

TABLE 1. Creole Petroleum Corporation's Transmission System.

		Size, in.	Length, miles	Capacity, bbl/day
I.	Crude oil trunk lines			
A.	Ulé-Amuay Pipe Line No. 1	24	26.2	300,000
		26	118.6	
B.	Ulé-Amuay Pipe Line No. 2	26	144.8	220,000
C.	Ulé-Punta Gorda	10	4.3	40,000
D.	Ulé-La Salina	26	9.1	400,000 (under construction)
E.	Punta Gorda—La Salina	16	4.8	
		10	4.8	
		10	4.8	300,000
		12	4.8	
		12	4.8	
F.	Lagunillas-La Salina	34	21.6	600,000
G.	Bachaquero-Lagunillas	24	16.5	120,000
H.	Pueblo Viejo-Lagunillas No. 1	24	14.8	111,000
I.	Pueblo Viejo-Lagunillas No. 2	34	14.8	180,000
J.	Mulata-Travieso	8	1.5	38,000
		10	5.8	
K.	Jusepín-Travieso	16	13.9	75,000
		8	2.2	
L.	Jusepín-Caripito	8	7.8	37,000
		10	38.4	
M.	Quiriquire-Caripito	16	3	80,000
		20	7.8	
N.	Temblador-Boca de Uracoa	10	34.2	20,000
O.	Temblador-Caripito	30	92	48,000 (planned)
II.	Products lines			
A.	Catia La Mar-Caracas	8	11	22,000

Pump Stations

		Prime movers		Pumps
I.	Crude Oil			
A.	Ulé No. 1	7- 940-hp	gas-diesels	reciprocating
B.	Dabajuro	7- 940-hp	gas-diesels	reciprocating
C.	Ulé No. 2	4-1650-hp	gas engines	centrifugal
D.	Lagunillas	4-1750-hp	motors	centrifugal
E.	Río Ulé	3- 150-hp	motors	reciprocating
		1- 250-hp	motors	reciprocating
F.	Punta Gorda	1- 250-hp	motors	reciprocating
		1- 200 hp	motors	reciprocating
		4- 75-hp	motors	reciprocating
G.	Mulata	2- 250-hp	motors	centrifugal
H.	Quiriquire	3- 300-hp	motors	centrifugal
I.	Jusepín	4- 250-hp	motors	centrifugal
J.	Temblador Sta. 5	3- 75-hp	motors	reciprocating
K.	Temblador Sta. TT-23	4- 500-hp	motors	rotary (planned)
L.	Temblador (booster)	4- 500-hp	motors	rotary (planned)
II.	Products			
A.	Catia La Mar	3- 640-hp	diesels	centrifugal

In Western Venezuela, Mene Grande has 67 miles of 8, 10, 12, and 24-in. pipelines, all moving crude.

Details of the Mene Grande system are given in Table 2.

Shell de Venezuela

Cia Shell de Venezuela has expanded its pipeline system in Western Venezuela markedly during the last six and a half years, having added close to 500 miles of lines.

One of the major trunklines is termed Lightline because it carries a light grade of crude oil. Completed in 1952, this 163-mile line extends from Palmarejo tank farm to Shell's refinery at Cardon, with an extension to Mene Grande's terminal at Las Piedras. Route is through Lake Maracaibo where two 20-in. lines were laid, otherwise the main line is 30-in. in diam.

Pagline, constructed this year, is a natural gas transmission line between La Paz and the Cardon refinery, a distance of 178 miles. The line was laid parallel to Lightline for the most part and is 20 in. in diam.

A third trunkline is a 14-mile artery that takes crude oil from the Tia Juana area to the Cabimas tank farm. The line is 14-in. in diam and has a capacity of 100,000 bbl per day.

Three main gathering lines have been constructed in recent years to take crude oil production from Lake Maracaibo. Lapline is the name by which a 47-mile gathering system is known that extends from Block 1 in the lake to Palmarejo tank farm. The underwater part of this system consists of 16-in. and 20-in. parallel lines with the land section 24-in. diam. Capacity is 340,000 bbl per day.

Also taking oil from Block 1 is Cabline, 17 miles of 20-in. pipe that extends to Cabimas tank farm. At a pressure of 900 psi this line has a capacity of 400,000 bbl a day.

Bachline connects Block 3 of the lake concession to the Bachaquero tank farm. The underwater part of this 14-mile gathering line is 10-in. in diam and the land section 12-in. Capacity is 35,000 bbl per day at 450-psi pressure.

Venezuelan Atlantic

Venezuelan Atlantic Transmission Corporation's gas pipeline system is somewhat unusual in that it serves industry 100 percent, none of the gas being used for domestic consumption.

Gas is gathered from high pressure gas wells and oil separators in the State of Guarico and delivered to a point called Lechoso. The 200-mile VATCORP system starts at this point, serves various industries in the Caracas Valley and Valencia Valley, and extends on down to the coast north of the City of Caracas. Primary customer in this coastal area is Electricidad de Caracas, which is the power company that supplies electricity to the City of Caracas.

The trunk line has a capacity of 87,000,000 cu ft a day at 900-psi pressure. Pipe diameter is 10, 12, and 16 in. for the trunk lines and 3, 4, 6, 8, and 10 in. for the distribution lines.

Socony Mobil

In its eastern division, Socony Mobil de Venezuela has 239.6 miles of crude oil line from the Guico and Oscurote fields to Anaco, thence to Puerto La Cruz. Pipe is 8, 10, and 12-in. diam to Anaco, and 12 and 16-in. to Puerto La Cruz. At an operating pressure of 900 psi, capacity is 200,000 bbl per day.

Anaco station is equipped with gas engines driving centrifugal pumps. Field stations have reciprocating pumps driven by gas engines.

In its western division, Socony Mobil is now testing a recently constructed 211-mile crude oil line from the Silvestre field to a terminal at El Palito. This 20-in. line will operate at a pressure of 1200 psi, with a capacity of 100,000 bbl a day. Pumping equipment consists of centrifugal pumps driven by diesel engines. Tank farm at Silvestre has a capacity of 600,000 bbl, and the terminal at El Palito a capacity for 1,337,500 bbl. The system will serve the Barinas area.

A detailed story on this new project appears elsewhere in this issue.

Government's Gas Program

The Venezuelan Ministry of Mines and Hydrocarbons has underway an ambitious program for a nation-wide pipeline network to make natural gas generally available to homes and industries. The system will be government owned and operated.

Last year a 43-mile, 12-in. gas line was completed for the Ministry of Mines and Hydrocarbons between Guacara and Morón, Carabobo State, which will supply a petrochemical plant under construction at Morón. The Petrochemical Bureau, a government agency, laid this line, and also will build and manage the gas transmission lines for the planned extensive network. City distribution systems will be constructed by the Venezuelan Development Corporation. The first such system will be in the Caracas metropolitan area.

For carrying out the program the country has been divided into three sections: Central, western, and eastern. A line is now under construction from eastern Venezuela oil fields, originating at Anaco and terminating at the La Mariposa power plant near Caracas. This is a 206-mile, 26-in. line and will have a capacity of 282,500,000 cu ft a day. From La Mariposa the line will extend to Valencia and Morón, with branches to La Victoria and Maracay, thence northwest from Morón to Coro and southwest to Barquisimeto. From Anaco a second line will extend northwest to Puerto La Cruz, and another south to El Tigre then southeast to Ciudad Bolivar. This system will cover the central section and a part of the western section.

As a part of the program, Las Mercedes oil fields in Guarico State will be utilized to supply other eastern towns, such as Valle de la Pascua, Tucupido, Zaraza, and Las Mercedes, and Colon District fields in Zulia State to supply the Tachira power plant and provide gas to domestic users in Tachira State. To the west, the states of Mérida and Trujillo, and possibly Portuguesa, will be supplied from Socony Mobil fields in Barinas State. ★ ★ ★

TABLE 2. Mene Grande Oil Company's Trunk Pipeline System.

Eastern Venezuela

From	To	Pipe diam, in.	Miles	Carrying
Oficina	Anaco	16	37	crude
		16	37	crude
Anaco	Puerto La Cruz	26	61	crude
		16	61	crude
Travieso	Puerto La Cruz	16	95	crude
KLM 135	Anaco	30	22	crude

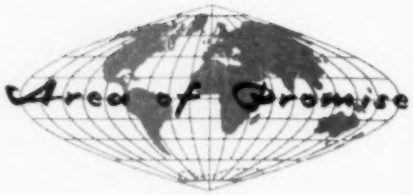
Projected: 30 in. line from Oficina to Puerto La Cruz, 76 miles of 6 in. LPG pipeline from Anaco to Puerto La Cruz, 61 miles.

Pump Stations

Station	Horsepower	Type prime mover	Type pumps
Oficina	3710	diesel	reciprocating
Anaco	4990	diesel	reciprocating
Travieso	2950	diesel	reciprocating
Puerto La Cruz	4000	electric	centrifugal

Western Venezuela

From	To	Diam, in.	Miles	Carrying
Bachaquero	Lagunillas	12	17	crude
Laguin PUS-1	Lagunillas	8	11	crude
Tasajeras	Lagunillas	10	3	crude
Taparito	Cabimas	12	11	crude
Ceuta	Bachaquero	24	25	crude



P 615.3

Route of Barinas pipeline from Silvestre field to El Palito.

Barinas Pipeline Nears Completion

Crude oil line from Silvestre field, in the interior of Venezuela, extends to tanker loading terminal at El Palito

SOCONY Mobil's discovery of oil in the Silvestre field of Venezuela confronted the company with the problem of transporting crude oil from the interior to a tanker loading terminal. To do so, the company decided to build a 211 mile long pipeline, following the shortest possible route between Silvestre and El Palito, located on the Caribbean, some 7 miles west of Puerto Cabello. It is designed for a daily throughput of 100,000 bbl at a maximum operating pressure of 1200 psi.

The route the new pipeline was to follow was decided upon only after several alternatives were ruled out as unsuitable. For instance, there existed terminal facilities in the Lake Maracaibo region. In the East, terminals were available at Puerto La Cruz. In each case, however, there were serious deterrents to following either of these routes. A line making use of the Lake Maracaibo terminals would have to cross the rugged Andes Mountains. To follow in the direction of Puerto La Cruz would have necessitated covering a distance of some 435 miles, requiring one or more booster stations.

In following the shortest possible line between Silvestre and El Palito, Socony Mobil also stayed clear of the highway right-of-way route it might have followed between those points. By doing so, the company avoided having to

Prepared by staff of Socony Mobil Oil Company, Inc.

Lining up a joint of pipe for the tack weld.

Firing line welders.

bury the line where it would have passed cities or towns, or crossed access roads to the highway.

For the first 100 miles, river crossings largely dictated exact locations for the line, because in the southern portion of the route rivers are wide and winding. Staying to the east of the Pan American Highway, the line passes through the San Felipe Valley. At one point the line almost touches the highway, and parallels it to the terminal.

The profile of the line maintains constant elevation of approximately 425 ft for the first 63 miles, then rises gradually for the next 62 miles to an elevation of about 1250 ft, from where there is a fairly uniform drop to its termination at El Palito.

Although the right-of-way crosses 116 pieces of property, in five states, no property was expropriated for right-of-way.

For the construction of the line, Socony Mobil purchased 40,000 tons of 20-in. API 5LX-52, high test line pipe, consisting of 5/16-in., ⅜-in., and ½-in. wall thickness. To withstand high pump pressures at the station, ⅜-in. wall pipe was used for the first 34 miles leaving Silvestre. The next 59 miles, to the future booster station site, is made up of 5/16-in. wall pipe. There follows a 21-mile section of ⅜-in. wall, with the remainder to El Palito being made up of 5/16-in. wall pipe. At all buried river crossings, ½-in. wall pipe was employed.

Line Laid Aboveground

As the line is a surface installation, concrete blocks at maximum intervals of 40 ft support the line 12-in. above ground. H-frame pipe supports, constructed from used drill pipe, were used for crossing swampy ground or small creeks. Over larger rivers and creeks, ranging in width from 60 to 200 ft, a total of 12 suspension spans were erected.

In the course of construction, 17 rivers exceeding 200 ft in width had to be crossed. The pipeline was buried at a depth of 6 ft below the deepest point, and carried at this depth the entire width of the river.

When river crossings required the line to be buried, the natural sag of the pipe, rather than sag bends or overbends, was used to accomplish it. In this way, the line can easily be lowered should future channel scouring or bank erosion of the rivers necessitate.

The ½-in. wall river pipe was coated, wrapped, and checked for holidays with a detector. It was weighted with concrete weights at 5-meter intervals to give it a negative buoyancy of 1.5 when empty and submerged in water. Magnesium anodes were installed for cathodic protection at each river crossing, and each section of river pipe was tested with water to 1400 psi before being pulled into place.

While the pipe was buried at major road crossings, dirt ramps were constructed over coated sections of the line to allow for trails, cattle crossings, and little used private roads.

Twenty-five block gate valves were installed on the line near all-weather access roads. A scraper trap was put at each end of the line.

To keep the last 86 miles of line full of oil, regardless of throughput, a back pressure regulator was installed at El Palito. As the throughput decreases, a valve will automatically throttle back, restricting the flow so that at no time will the line tend to void.

Work on the line started the first week of November 1956, at the booster station site. There were two reasons for this starting point: First, the area near Silvestre was still wet from the previous rainy season making it extremely difficult for vehicles and work equipment to pass. Secondly, the 5/16-in. wall pipe was first to arrive and could

Main line gate valve at El Palito.

The pipeline has a visitor. Venezuelan collecting firewood gives job the once-over.

Canopy gives welders protection from hot Venezuelan sun.

be strung and laid back toward Silvestre without loss of time.

Laying of the pipe was completed in six months, with an average laying rate of 6900 ft per day. During a record day 338 joints were laid, totaling well over 16,000 ft.

Until the beginning of the rainy season, heavy dust along the right-of-way proved one of the main obstacles. This dust built up to a depth of more than a foot, frequently choking out engines of ordinary vehicles.

Silvestre Station

The Silvestre station is serviced by two 16-in. production lines from the producing areas. A 24-in. suction line and an electrically driven 150-hp booster pump provide suction to the main line pumps.

The tank farm, consisting of four 150,000-bbl standard API floating roof tanks equipped with remote reading gages and two electric mixers per tank, has a positive displacement metering installation to measure oil flowing into the tanks. The purpose of this metering installation is to check the results of hand gaging versus meters. Once the meters have been proved accurate, permission will be sought from the government to gage the oil through meters. The meter installation will be equipped with a weir type prover tank, continuous samplers, and recording gravitometers. BS&W monitors will sound an alarm should an excessive amount of BS&W appear in the incoming lines.

Three V-type, 16-cylinder, turbocharged, dual-fuel engines power the pump station. Each engine develops 2000 hp at 1000 rpm, and will use crude oil from the line as fuel. By means of speed increasers, these engines will drive two-stage, 12-in. by 12-in. centrifugal pumps.

For throughput of 100,000 bbl daily, two units will operate in series. When the daily production exceeds this rate, the third unit will be operated in series, and a fourth unit installed as standby. Three similar units will then be required at the booster station with a fourth unit as a standby. With this equipment, the pipeline could easily handle 150-160,000 bbl daily.

An electric generating system, composed of two dual-fuel engines identical to those used with the pumps, mounted with 1500 kw/4160 v electrical generators, will supply the station, tank farm and the producing fields with electricity.

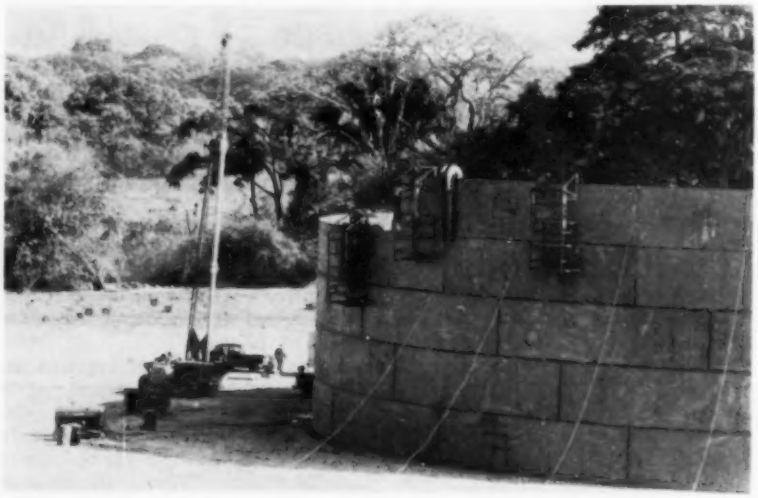
Automatic Controls

Automatic controls and safety devices, as well as electric motor operated valves, will be installed throughout the station. They can be supervised from a central control room, which will have a schematic layout of the station with switches and operation indication lights for tank mixers, booster pumps, motor operated valves, and roof ventilators.

Storage tank levels and engine speeds will be indicated by gages, and there will be automatic controllers and recorders for station discharge pressure, suction pressure, and flow.

Visual and audible alarms will signal warnings in case of high station discharge pressure, low station suction pressure, station flow not within desired range, high engine speed, high pump bearing temperature, high pump case temperature, pump seal failure, high sump level, instrument air failure, and BS&W content above limit.

The station is equipped with a water spray and foam fire control system, which works automatically and also can be used manually. Fire fighting equipment will be placed at strategic locations throughout the station and tank farm areas. ★ ★ ★



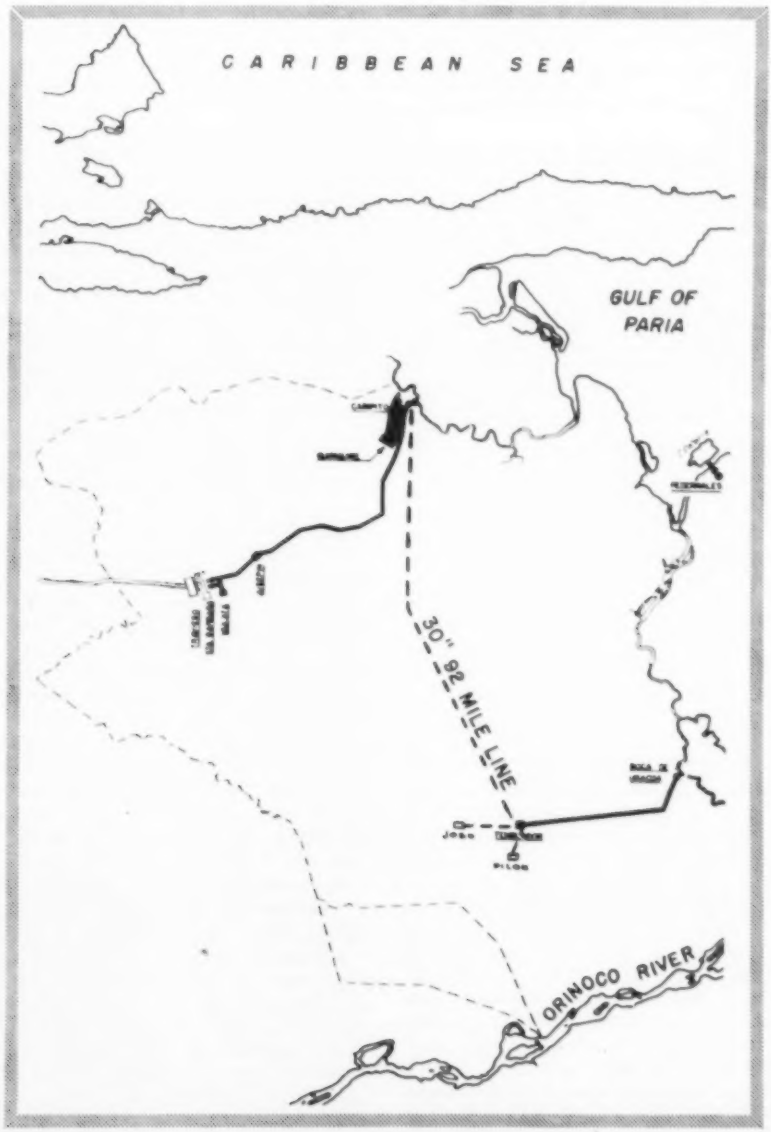
Tank construction at Silvestre.

Clearing the right-of-way ahead of the ditchers.

Robert W. Leach
Creole Petroleum Corporation
Caracas, Venezuela

Pipeline Designed for Viscous Crude

After investigating many possibilities, Creole selected a 30-in., unheated, aboveground line—Here are the reasons



Route of 92-mile, 30-in. pipeline from Temblador to Caripito, Venezuela.

CREOLE Petroleum Corporation is now proceeding with the design and construction of a 30-in. pipeline to transport approximately 48,000 bbl per day of viscous crude oil from Temblador in the southern part of the State of Monagas to the Caripito refinery and terminal 92 miles north on the San Juan River. This crude may have a gravity as low as 11 deg API and, at an early morning temperature of 75 F, a viscosity of 60,000 SSU.

Selection of the most economical pipeline for a crude having such an unusually high viscosity was an interesting problem, because of the large number of possibilities presented. Following is a discussion of the various possibilities that were investigated and the reasoning that led to the final selection of a 30 in. diam unheated, aboveground line.

The Possibilities

The various types of lines considered were:

1. An aboveground, uninsulated, heated line.
2. An aboveground, insulated, heated line.
3. An underground, heated line.
4. An aboveground, unheated line with water added to the crude oil to reduce friction loss.
5. Two pipelines, one of which would bring a diluent from the terminal end of the crude pipeline to its initial pump station for mixing with the crude to reduce its viscosity.
6. Two pipelines, one of which would bring lighter crude oil from another oil field to the initial pump station of the pipeline for mixing with the heavy crude to reduce its viscosity.
7. An aboveground, unheated pipeline.

In considering the aboveground, uninsulated, heated line, it was found that, although heating is extremely effective in reducing viscosity, the crude oil would soon lose most of this heat because of low velocity through the

line and the high coefficient of heat transfer between the line and surrounding air.

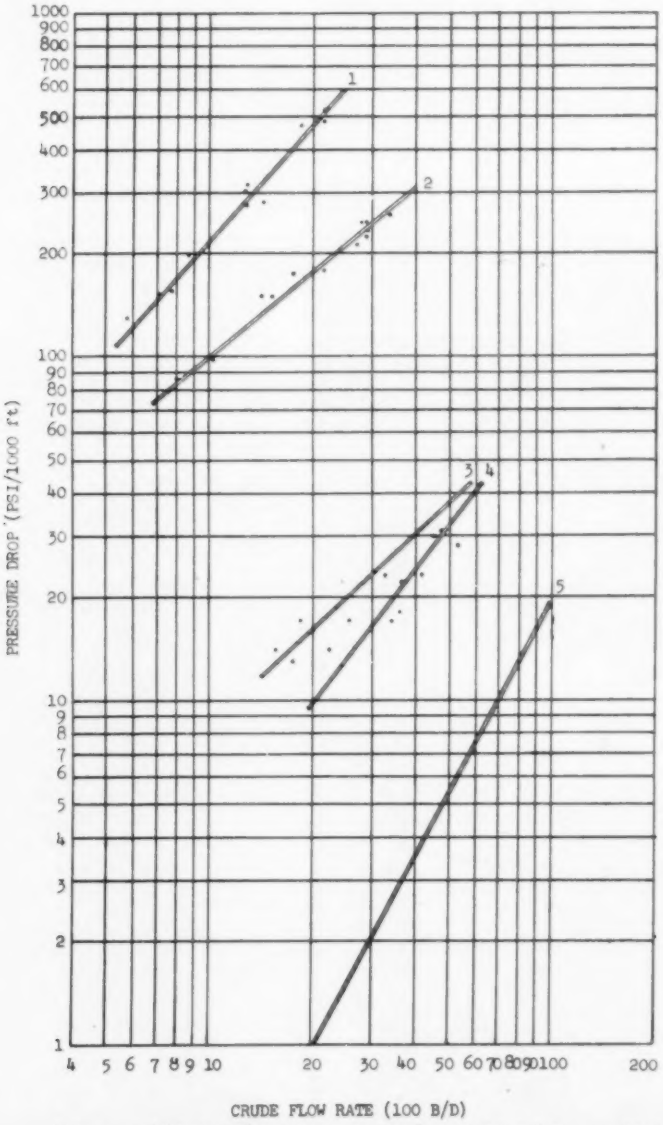
In making calculations, temperatures and the corresponding crude viscosities were computed at points two miles apart for the entire line using an overall coefficient of heat transfer of 2 Btu per sq ft per hr per deg F. Varying the number of heater stations and the temperatures to which the crude is heated makes it possible to use various diameter lines. In this case, using the most economical diameter for the heated line, it is possible to reduce the size of an aboveground line from 30 in. diam to 22 in.; however, the cost of the crude burning heater stations would be greater than the saving realized from reducing the size of the main line. As both initial investment and operating cost were greater for this line than for an aboveground, unheated line, which is the conventional type of pipeline in Venezuela, it was not given further consideration.

In view of the large heat loss of a bare heated line exposed to the atmosphere, consideration was given to an insulated aboveground line; however, it was not possible to find an effective insulation that was inexpensive enough to be economically justifiable.

Buried Heated Line

The next type of line considered was a heated line, buried to permit the soil to act as an insulator. Burying is not normally required in Venezuela and practically all pipelines in the country are aboveground.

The overall heat transfer coefficient for a buried line is considerably less than for an exposed line, and therefore the viscosity of the crude increases after leaving the heater stations at a much reduced rate. This makes it possible to effect the economy of using fewer heater stations and 18-in. rather than 22-in. diam pipe. The additional expense of coating, wrapping, and burying the pipe largely offsets this economy, however, and this line has an initial investment only slightly less than that for the heated line exposed to the atmosphere. With a buried line and fewer heaters the operating costs are less than for an aboveground heated line and more than for a large diameter aboveground unheated line. As the investments for the buried line and an unheated aboveground line were nearly the same, the unheated line with a lower operating cost was more attractive.



Pilón pumpability test. Flow rate vs pressure drop. Test installation consisted of 1000 ft of 4½-in. diam, 0.237-in. wall thickness pipe. (1) 32,000 SSU crude. (2) 16,000 SSU crude. (3) Water injection, 32,000 SSU crude. (4) Water injection, 16,000 SSU crude. (5) Pure water.

What of Water Injection?

Injection of water into a crude oil pipeline to reduce friction loss has been done successfully in western Venezuela, so the possibility of using water injection for this pipeline was seriously investigated. A test installation was made in the Temblador area to determine the reduction in pressure drop resulting from the injection of various percentages of water in a crude stream of 13.4 deg API Pilón crude having a viscosity of 17,000 SSU at 90 F. The installation consisted of a loop of 1000 ft of 4½-in. diam pipe, two 1000-bbl tanks, one 200-bbl tank, one reciprocating crude pump, one reciprocating water injection pump, meters, and instruments.

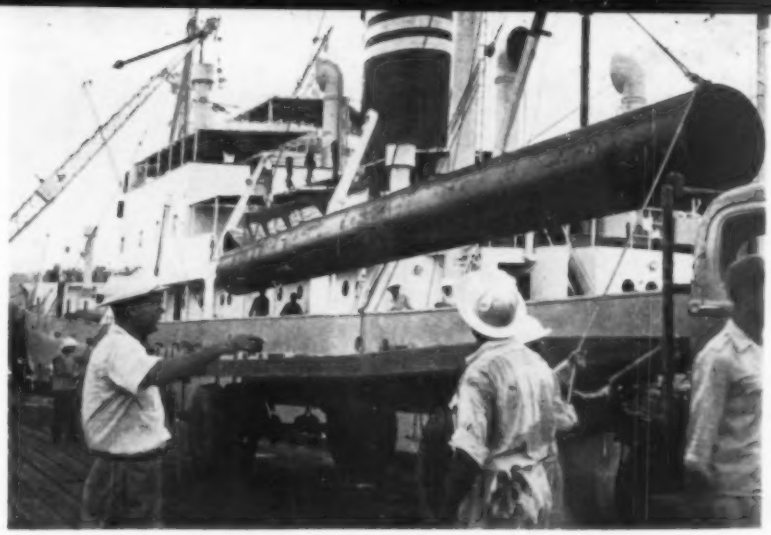
Reduction in pressure drop resulting from the addition of water was quite large. For example, when pumping 2400 bbl of crude per day with water, the pressure required was 94.8 percent less than that required to pump pure crude. In this case, 214 psi was needed to pump 2400 bbl per day of crude through the 1000 ft of 4½-in. line and 11 psi for pumping water plus 2400 bbl per day of crude. A graph of the flow rate vs pressure drop test results is shown in Fig. 1.

The amount of emulsion formed during these tests varied from 4.5 to 7 percent for additions of water varying from 12.5 to 32.4 percent. In general, the amount of emulsion formed varied directly with the amount of water injected. As there existed the possibility that an emulsion having a viscosity as great as the pure crude oil might be formed under certain conditions, it was desired to learn how much

and what kind of emulsion might be formed in a 92-mile line, but, unfortunately, with this test installation of 1000-ft of pipe, it was not possible to determine the effect of length of line on the formation of emulsion.

After obtaining the above favorable test results, estimates were prepared for the main line to determine the initial investment and operating cost for the 92-mile pipeline with water injected only at the initial pump station. Because of reduced friction loss resulting from water injection it was possible to show a large saving in main line investment by using a 20-in. line rather than the 30-in. line that would be required without water injection. This saving was offset to some extent by the cost of the dehydration units required at the Caripito end of the line, yet the total investment was still considerably less than for the larger line without water injection. Even after taking into consideration the operating cost for this system, which was relatively high due to the expense involved in dehydrating the crude, it was attractive. Even so, there existed serious misgivings concerning this type of pipeline, because the hydraulics of a water injection system are not well understood. There was particular concern about the possibility of the formation of large percentages of emulsion during the period of more than the three days the combined oil and water would require to travel the length of the 20-in. line. If the extent of emulsification were very great, possibly no pressure drop reduction would result from water injection, and the 20-in. line would not be able to handle the design capacity of 48,000 bbl per day.

Had the water injection line been selected, a considerable saving in initial investment would probably have been realized, and if, upon operating the water injection system, the formation of emulsions proved to be no problem and operating cost proved to be as anticipated, this line would have been the best selection. In view of the large investment involved, however, and the considerable amount of uncertainty that existed concerning the formation of emulsions, dehydration of the crude, and pumping difficulties after a shutdown, it was concluded that the construction of a water injection line could not be justified at this time.



Unloading pipe from ship at Caripito.

Mixing Naphtha With Crude

In view of the fact that the 32,000 SSU viscosity at 85 F of the crude could be reduced to approximately 1550 SSU with the addition of 15 percent naphtha, which was available at the Caripito refinery, consideration was given to pumping naphtha to Temblador for mixing with the viscous Pilón crude. It was found that a 6-in. line was adequate for pumping the naphtha 92 miles south to Temblador and a 20-in. line was adequate for pumping the diluent crude 92 miles north to Caripito.

Investment for the two lines, tankage, and pumping equipment would be less than for a 30-in. line required for undiluted crude. Had the refinery had sufficient spare capacity to process the additional amount of naphtha involved, this line would have proved to be the best selection. Study indicated, however, that the cost of the additional refinery processing equipment required would make the cost of this diluent system exceed that of a 30-in. line without a diluent. Although the diluent system was given no further consideration for use as a main line, it was realized that the installation of a diluent line in the future probably would be an economical method of increasing the capacity of the 30-in. line that was finally selected.

In regard to a possibility of pumping lighter crude from a source in the adjacent State of Anzoátegui to the initial pump station for use as a diluent, it was found that, although a considerable reduction in viscosity could be effected, the lighter crude oil was so much less effective as a diluent than naphtha, and the cost of the light crude pipeline so high, that this system was not economically feasible.

The Line Finally Selected

In the calculations to determine the economic diameter for an unheated aboveground line, a design viscosity of 32,000 SSU at 85 F was used. The most economic line size, that is to say the line with the optimum combination of initial investment and operating cost, proved to be a 30-in. line having two pump stations and a maximum pipe wall thickness of 3/8 in. It was originally planned to use 30-in. by 1/4-in. pipe for a large portion of this tapered line, but, as the 1/4-in. wall pipe proved to be unavailable, this was changed to 5/16-in.

This is the line finally selected. It was chosen in preference to the others, except the one involving water injection, on the basis of economics. It might be observed, however, that were it necessary to bury this line, probably a heated line would have been the best selection.

Another consideration that has made the 30-in. line desirable is the many possibilities that it presents for increasing capacity economically in the future. Among these are the addition of two unattended booster stations, and the methods previously discussed of heating the oil using heaters burning crude oil, injecting water and adding dehydration facilities at the end of the line, or adding a diluent. In addition, there remains the possibility of increasing the amount of heat absorbed by the pipeline from the sun by painting the line with a coating that will decrease the emissivity of the pipe surface without decreasing its absorptivity. It is believed that such a coating would reduce significantly the viscosity of the crude in the line and would correspondingly increase the capacity of the system. ★ ★ ★

The Author

Robert W. Leach is an engineer in the production department of Creole Petroleum Corporation, in Caracas, Venezuela. He is presently engaged in making economic studies concerning pipeline and marine terminal facilities. Born in Pennsylvania, Leach received a BS degree in mechanical engineering from Cornell University and is a registered professional engineer. He worked for eight years as a project engineer in the chemical industry before joining Creole in 1954.

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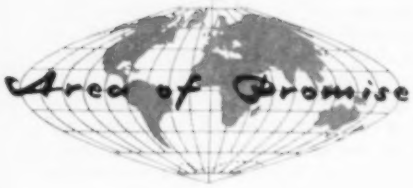
FIG. 1. Adjacent rights-of-way of 8-in. refined products line and 12-in. industrial gas line crossing the Coast Range north of the City of Caracas, Venezuela.



Venezuela's Corrosion Problem Is a Special One

Soil and climatic conditions must be understood for a successful program to be mapped

Charles R. Landers
Resident Engineer
Venezuelan Atlantic
Refining Company
Transmission Corporation

PROBLEMS facing the corrosion engineer when first considering a project in Venezuela often appear unique; however, once the special conditions of climate and terrain are fully understood, the problem is usually solved with techniques and materials with which he already is familiar. Although the specific subject of this discussion is external corrosion control of oil and gas pipelines in Venezuela, the information should be of value in any area of similar soil and climatic condition.

At the present time, oil and gas pipelines are being operated in the jungles and rain forests of eastern Venezuela, the llanos of north central Venezuela, the Coastal Range along the north coast line, in the foothills of the Andes, and along the coast and under the waters of Lake Maracaibo. A small amount of offshore line has been laid and this will increase within the foreseeable future.

There are two seasons for most of Venezuela. The rainy season starts in June and lasts until December. During these periods most pipeline rights-of-way are practically inaccessible. The alternate dry seasons are the other extreme. Little or no rain falls during these periods and the soil is almost void of any moisture. The Maracaibo Basin is hot and dry most of the time with occasional heavy rains.

Soil resistivities of most soils and inland waters range from the medium ranges through the highs and extremely highs. During the dry seasons, soils will be in the higher ranges due to loss of moisture; thus, corrosion practically ceases during this period. This factor can be a great influence on the economic considerations of corrosion mitigation.

The familiar techniques of corrosion surveying are of limited value. During the rainy season the rights-of-way are practically impassible and during the dry season the rate of corrosion is reduced to the point that detection is very difficult, if not impossible.

As most pipelines are layed bare on the surface of the ground, physical inspection of the pipe is facilitated. The pipe pit gage is one of the most valuable tools available. The speed of a physical inspection survey compares quite favorably with a pipe-to-soil potential or surface potential survey.

Soil resistivity surveys conducted during the dry seasons are generally worthless. A study has been undertaken to determine whether correlation exists between soil resistivity during the rainy and dry seasons, and absolutely no correlation has been observed. If cathodic protection with rectifiers is contemplated, a current requirement test conducted during the rainy season will provide the most valuable information available. It must be accepted that only a limited number of potential measurements can be obtained due to right-of-way accessibility; but, it has been found generally that sufficient data can be obtained to correlate the survey.

FIG. 2. Pit depth is measured by engineer on physical inspection survey of 16-in. surface line.

Line Blocking Widely Used

Line blocking is probably the most widely employed corrosion mitigating device used in Venezuela. This is the common name applied to the placing of supports, generally concrete, under the pipe to separate the pipe and soil physically. Where right-of-way clearance can be obtained, line blocking is the most economical and trouble free type of corrosion mitigation that can be had.

The best time to employ line blocks is during initial construction. If a surface line is planned, suggest to your management that bids be procured both for a surface line and a blocked line. The small differential cost for line blocking may come as a pleasant surprise. An operating line can be blocked easily, but great care must be exercised in handling slack and provisions have to be made for normal line expansion and contraction. Both problems generally are solved by proper design.

FIG. 3. Concrete support block on 16-in. crude oil line. Lift-holes for handling blocks are visible at each side of block.

Design of pipeline supports requires the corrosion engineer to move over into the field of the structural engineer. Typical of most structural design problems, the design of pipeline supports is a compromise. The block spacing is a compromise between sufficient deflection to compensate line expansion and the allowable working stress of the pipe. Similarly, the block is a compromise between the soil bearing surface and the weight.

The best place to start on the design of pipeline supports is the determination of the spacing. If desired, the spacing can be calculated by using the information available in any standard structural handbook; however, a much easier solution is available. Tube Turns Bulletin TT726 entitled "Supports and Anchors for Piping" contains graphs of span versus pipe size for lines carrying both water and gas. Unfortunatley, these graphs must be extrapolated for big-inch lines. Data thus obtained have been found to be reliable. This span

The Author

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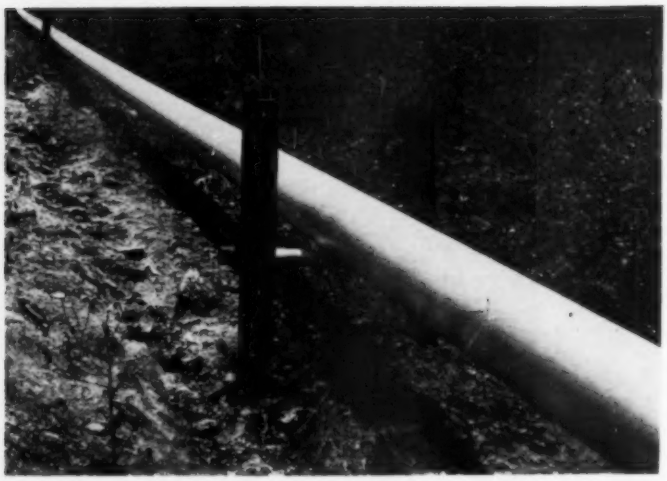

FIG. 4. H-frame supports on 8-in. refined products line. Concrete footings are not visible.

spacing should result in some sag or deflection between supports. The sag is very important to compensate for thermal expansion and contraction.

Design of Supports

Once spacing is determined, supports can then be designed. Several materials have been used for supports such as junk pipe and hard-wood timbers, but the most commonly used material is precast concrete. The two types of concrete support in common use are the obelisk (frustum of a rectangular pyramid) type, (Fig. 3) and the two-piece type. The two-piece block consists of an obelisk type support resting on a rectangular foundation block. The obelisk type of support is the more common type and probably

FIG. 5. Concrete block supported pipeline passing through the llanos of north central Venezuela.

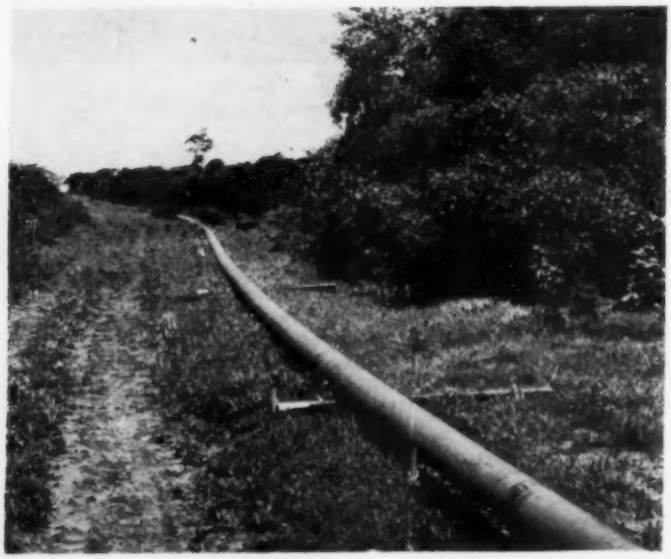

FIG. 6. View of sliding supports at angle point of a pipeline to permit thermal expansion.

will be the most economical for all sizes weighing less than 500 lb. It has been found that a support exceeding this weight becomes difficult to handle. When a heavier support is required, the two-piece type divides the weight between the saddle block and the foundation block; also, the lighter weight saddle block facilitates adjustment.

Design of the support is a compromise between bearing surface available and weight. Suitable formulae to calculate the bearing surface required from the known data of load and bearing of the soil are readily available. Once the bearing surface is determined, the type, size, and reinforcement of the support can easily be determined.

When line blocking is specified as a part of new construction, it is customary practice to set the supports first. The line then is progressively placed directly on the supports con-

current with welding. This type of construction practically eliminates the problem of slack and thermal expansion as the line will adjust to the supports during the construction period.

Special precautions have to be taken to handle thermal expansion. Forces set up in the line result in longitudinal movement. Affect of this movement can cause considerable lateral shifting at angle points. As the forces involved are sufficient to cause the pipe to jump off or over-turn the supports at these points, it is necessary to provide some sort of sliding block. This usually takes the form of a long rectangular block of concrete or junk pipe H-frames as shown on Fig. 6.

To prevent erosion damage to the pipe wall at the point of contact between the line and sliding block, a patch should be tack-welded to the pipe as shown on Fig. 7. Often when H-frame supports are used an attempt is made to lubricate the steel contact surfaces with heavy grease. This is of questionable advantage as the lubricating value is soon lost due to contamination with dust and dirt.

Some erosion has been observed at the point of contact on concrete saddle blocks. Coating the contact area of the block with a ¼ in. layer of 150 to 160 F softening point asphalt will minimize this erosion. It is recommended that yearly inspections of all supports be made so preventive maintenance can be undertaken to avoid damage to the pipe. A simple visual inspection is all that is required and, generally, the occasional addition of a patch at the point of contact is the maintenance required.

FIG. 7. Detail of patch tack-welded on pipe to prevent damage to pipe wall by erosion against sliding support.

FIG. 8. Conventional rectifier installation for cathodic protection of a 10-in. industrial gas line. Unit is situated inside customer plant yard and utilizes plant generated power.

Cathodic Protection Limited

Opportunities for utilizing cathodic protection are limited due to the prevalence of high resistant soils and limited availability of a-c power. Wherever applicable cathodic protection has been found to be very effective.

The difficulties of utilizing sacrificial anodes in high resistant soils is a familiar problem to the corrosion engineer. In Venezuela, cast magnesium anodes generally have been limited to the protection of river and road crossings. Although ribbon anode has not as yet been used in Venezuela, the advantages of this form of anode in high resistant soils merit consideration.

The conventional rectifier installation is severely limited by availablility of a-c power. As the results to be obtained from rectifiers are so superior to any other means of cathodic protection, it is recommended that all sources of electric power be given consideration. A-c power usually can be obtained from pump and compressor stations, as well as from various other sources such as small towns and industrial installations. Motor-generator sets can be used in areas where no other power is available. Fig. 8 shows a rectifier installed within a customer plant yard for protection of a 10-in. industrial gas line. This unit utilized plant-generated power.

Buried lines usually are coated with one of the standard types of composite coating. A special problem exists in the water of Lake Maracaibo, the teredo. This particular species of teredo is capable of boring through the normal composite coatings. In the past it was the general practice to lay lines bare in the lake. This avoided the accelerated corrosion damage that would result from coating failure. Recently, three methods of combating this problem have been used:

1. Concrete jacket,
2. Bury below mud-line,
3. Aluminum pipe.

At present no generalized statement as to the relative merits of these three methods can be given. The economics of each installation probably will determine the type of construction most desirable.

The trained corrosion engineer is already well equipped to solve the corrosion problems existing in Venezuela. When he has arrived at an appreciation of the prevailing soil and climatic conditions, he will experience little difficulty in the fulfillment of his professional undertakings. ★ ★ ★

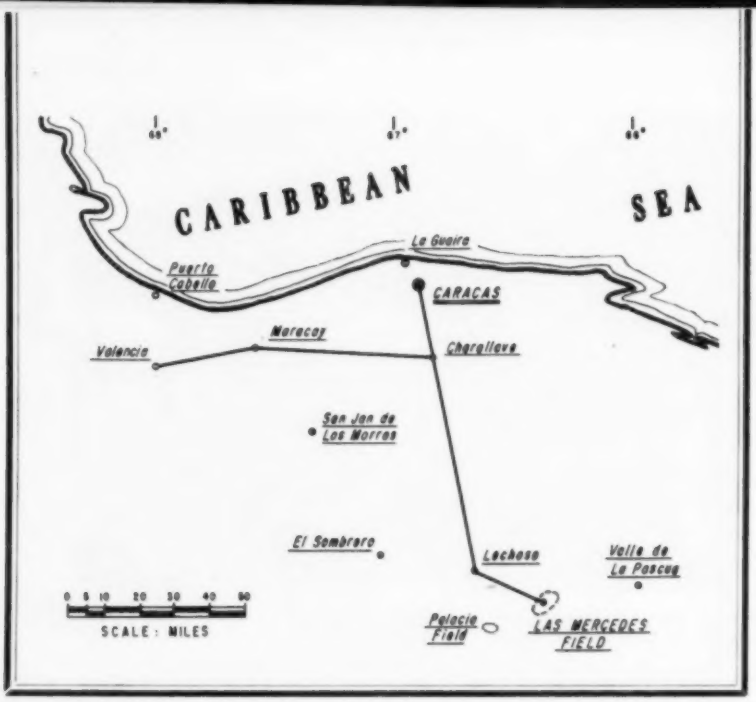

FIG. 1. Map of Central Venezuela showing location of SAPLM Mercedes and Palacio oil fields and main portions of VATCORP gas pipelines.

Here's how SAPLM gas gathering operations are set up in Guarico State to supply energy to industries and cities

Fuel Gas for Venezuela's Progress

M. A. Romero

UNKNOWN to most residents of Venezuela, Guarico State's dusty, undeveloped "llano" has been providing vital fuel for many of Central Venezuela's well-known modern wonders. Source of natural gas behind Caracas' nightly electric glitter, the Compañia Petroquimica's nitrate plant in Puerto Cabello, and Valencia's industrial boom are the SAPLM[1] Las Mercedes and Palacio oil fields (Fig. 1) 200 road miles south of Caracas. Here, oil separator gas compressed from 30 psi and 250 psi merges with high-pressure well gas for delivery at 900 psi to the VATCORP[2] 250-mile main gas pipeline system.

[1]Sociedad Anonima Petrolera Las Mercedes, jointly owned by Texas Petroleum Company (wholly owned subsidiary of The Texas Company), the operator, and Caracas Petroleum Sociedad Anonima (wholly owned subsidiary of Ultramar Company Limited, of London, England).

[2]Venezuelan Atlantic Transmission Corporation, wholly owned by Venezuelan Atlantic Refining Company (VARCO).

With the only integrated gas gathering and sales operation of its kind in Venezuela, SAPLM prevents the flaring of some 40 million cu ft of gas per day and taps sizable gas reservoirs. The result: Gas reserves in one of the nation's remotest oil fields become fuel for Venezuela's progress today.

Heart of the SAPLM gas operation is the 250 to 1000 psi, 5280-hp main compressor station shown in Fig. 2. Main arteries of the system are some

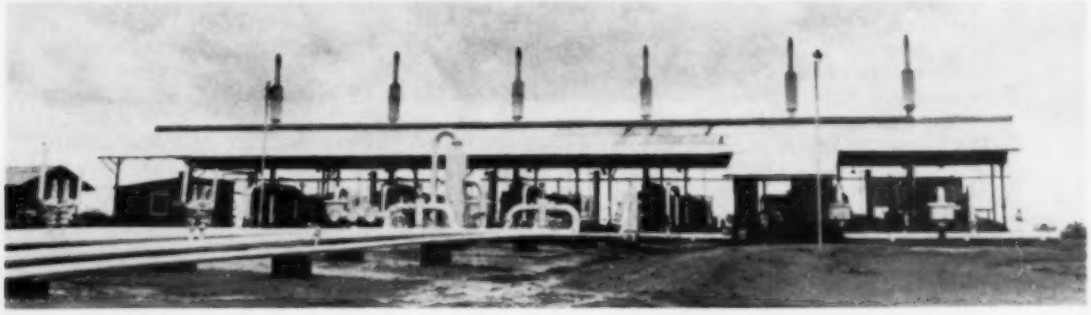

FIG. 2. Front view of main compressor station.

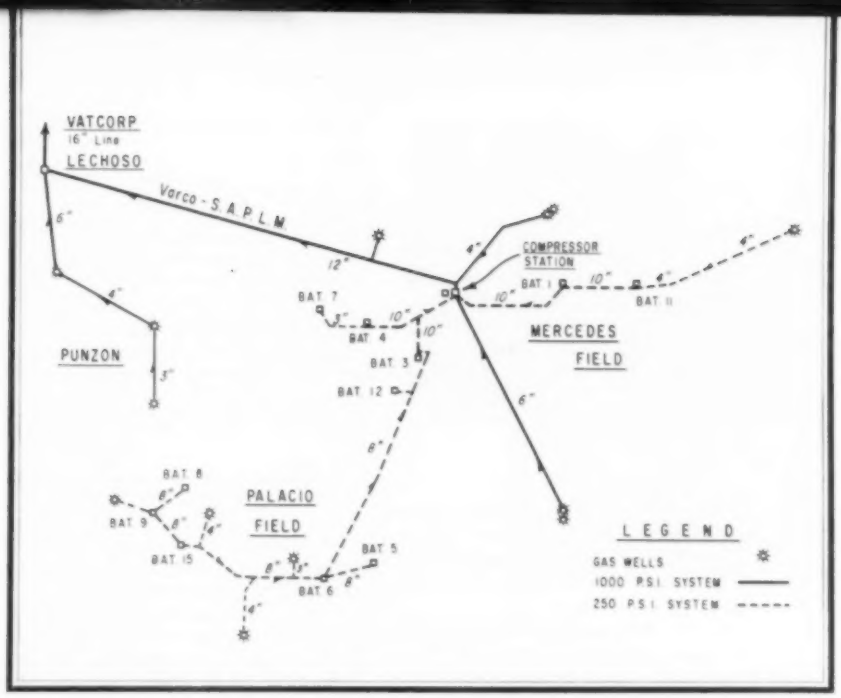

FIG. 3. Diagram showing principal components of SAPLM gas-gathering system.

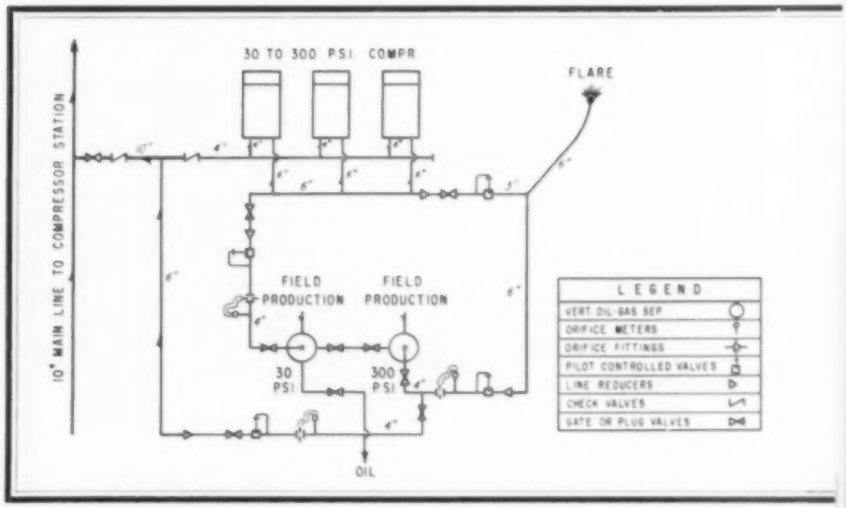

FIG. 4. Schematic diagram of a typical gas-gathering installation at an SAPLM field battery.

42 miles of 10-in. and 8-in. trunk lines which bring the bulk of the oil separator gas produced in the field to the main station at 250 psi.

250 Psi System

Feeder system for the main compressor station (Fig. 3) ties together 10 field batteries. This group of batteries includes every oil gathering station producing commercial quantities of gas and produces over 80 percent of the oil separator gas produced in the Mercedes and Palacio fields. Eight intermediate pressure gas wells also produce into the 250 psi system.

At each battery, gas is gathered from intermediate and low-pressure oil separators (Fig. 4 and 5). Packaged, skid-mounted, battery compressors such as those shown in Fig. 6 boost the low-pressure separator gas to gathering line pressure. This pressure varies between 300 psi and 500 psi depending on the distance from the main compressor station.

FIG. 5. SAPLM field battery, showing (l. to r.) separator gas compressors, oil well production manifold, and oil-gas separators.

The 19 battery compressors are gas-engine-driven, 2-stage units ranging in size from 150 hp to 350 hp. Totaling 4250 hp, these include 15 right-angle, 2-cycle-engine units with vertical-draft radiators and 4 V-type, 4-cycle-engine units with horizontal-draft radiators. Each is mounted on a concrete mat and covered by a shed. In the latest units installed, inlet and outlet scrubbers are mounted on a small skid bolted to the compressor skid, and all gas piping is prefabricated at the factory. A typical battery compressor layout is shown in Fig. 7.

Most units have individual starting

FIG. 6. Separator gas compressor installation at a field battery.

The Author

The author, Marco A. Romero, is district engineer at Roblecito, center of operations for S. A. P. Las Mercedes, a company jointly owned by The Texas Company and Caracas Petroleum, S.A. Mr. Romero is a graduate in business administration of the University of Puerto Rico and also holds a BS degree in mechanical engineering from the California Institute of Technology. He was originally employed by The Texas Company in Texas. After his return from military leave in 1952, he was transferred to Venezuela and was assigned to the Mercedes company in November 1953.

air compressors and all have gas intercooling and aftercooling. Fuel used for starting is oil separator gas from the battery; after starting, the normal fuel supply from the inter-stage scrubber is switched on.

Main Compressor Station

The main compressor station, which is shown schematically in Fig. 8, consists of six 880 hp, right-angle, 2-cycle, gas-engine-driven, permanently mounted compressors. Three units are single-stage and three units are 2-stage without intercooling. All units provide gas after-cooling. The individual cooling systems have vertical-draft radiators (Fig. 9) and are driven by the compressors, five of them through jackshafts, one of them through a hydraulic system.

At the station entrance (Fig. 10) two 10-in. lines lead into two scrubbers, a 4 by 13-ft vertical separator and four dust filters, and thence to the 20-in. suction manifold. Station suction pressure is maintained at 250 to 265 psi by a pilot-controlled valve. At the station discharge (Fig. 11), twin 8-in. manifolds lead to 2 by 15-ft scrubbers, pulsation dampeners, and from there to the 12-in. sales line. All units are tied to a common starting air system. Fuel used is 30 psi separator gas piped from neighboring Battery 2.

Maximum station capacity is 60 million cu ft per day. All workable compressors are run at all times; there is no stand-by unit. One operator runs the station, the only attended installation in the entire gathering system. He maintains radio contact with the VATCORP radio network and the SAPLM field radios. He also controls the inlet, just downstream of the station, of two high-pressure gas producing areas.

1000 Psi System

The main compressor station and, at present, eight high-pressure gas wells entering at three area inlet points such as the one shown in Fig. 12, compose the 1000 psi system. The station is on-stream full time and normally handles 80 to 90 percent of the SAPLM gas sales; the high-pressure wells are used

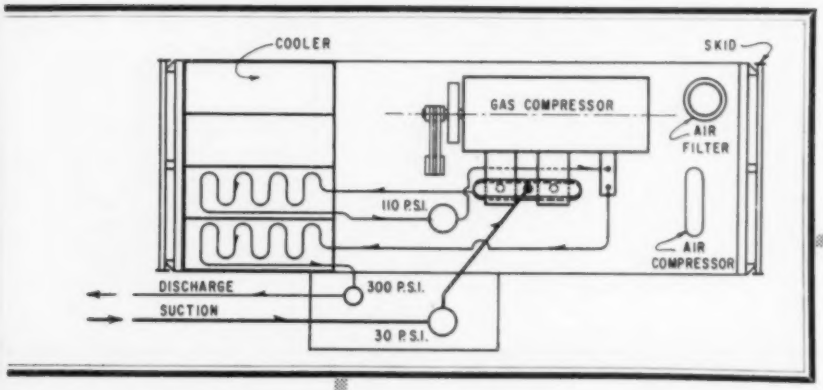

FIG. 7. Schematic diagram of a typical skid-mounted, packaged, separator gas compressor at an SAPLM field battery.

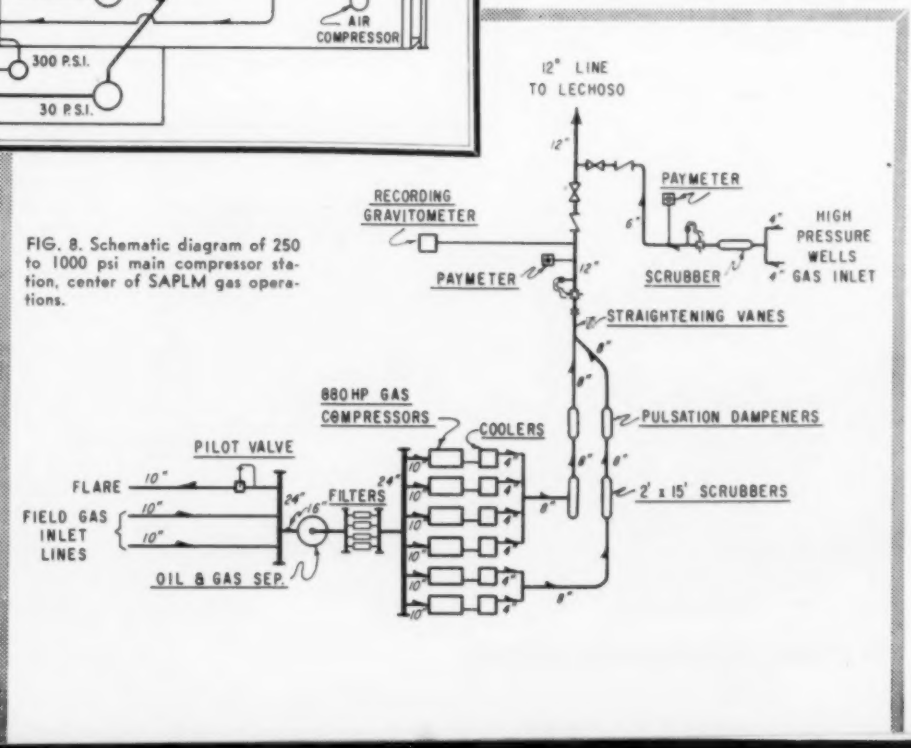

FIG. 8. Schematic diagram of 250 to 1000 psi main compressor station, center of SAPLM gas operations.

mainly for make-up during periods of peak demand. The station and the high-pressure wells discharge into the 12-in. 19-mile trunk line, shown in Fig. 3, which runs from the center of the Mercedes field to the Lechoso dehydration plant. This trunk line and dehydration plant are jointly owned by SAPLM and VARCO and operated by the latter. Lechoso is the inlet point for the Punzon high-pressure area and also the starting point of the VATCORP line to Caracas, Valencia, Maracay, Puerto Cabello, and other Central Venezuelan cities (Fig. 1).

Gas Wells and Lines

Most gas wells are 4000 to 5000 ft in depth, dually completed with 5-in. casing, 2½-in. tubing, side-door choke, series 600 Christmas tree and ram-type tubing head. All wells have positive beans and hi-lo pilot valves. A typical wellhead installation is shown in Fig. 13. Liquid corrosion inhibitor is injected into each producing zone once a month.

Production of gas wells is, on the average, restricted to 10 to 20 percent of open-flow capacity, with typical production of 2 to 4 million cu ft per day and maximum instantaneous rates of 6 to 8 million cu ft per day. Production rates are limited because most reservoirs in the area have fairly strong water drives and, consequently, water coning or channeling is common.

Lines are aboveground, welded and, if 4-in. or above in size, mounted on cement blocks. Road crossings are protected by plastic wrapping and magnesium anodes. Gas-driven chemical pumps inject liquid corrosion inhibitors into the gathering lines linking the batteries. Line leaks or breaks have, so far, been practically non-existent.

Metering

Paymeters consisting of mercury-type orifice meters and temperature recorders are located at every outlet from the SAPLM system. The paymeter at the main compressor station, which handles most of the SAPLM gas sales, also includes a recording gravitometer. Fig. 14 shows a typical paymeter installation.

Mercury type or liquid-filled bellows-type orifice meters, without temperature recording, are standard for all internal metering. Twenty-four hour clocks are used on all meters except at gas wells; seven-day clocks are used in gas wells, due to the remoteness of many well locations. All charts, except paymeter charts, are calculated manually; paymeter charts are machine-integrated by VATCORP. At the batteries, gas is metered at the compressor inlet and at the intermediate pressure separator discharge. Well gas is meas-

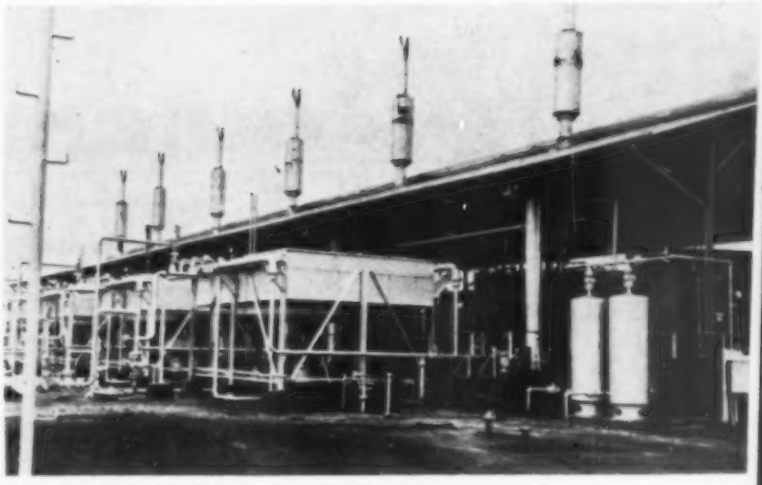

FIG. 9. Vertical-draft radiators for individual 880-hp compressors at the main compressor station.

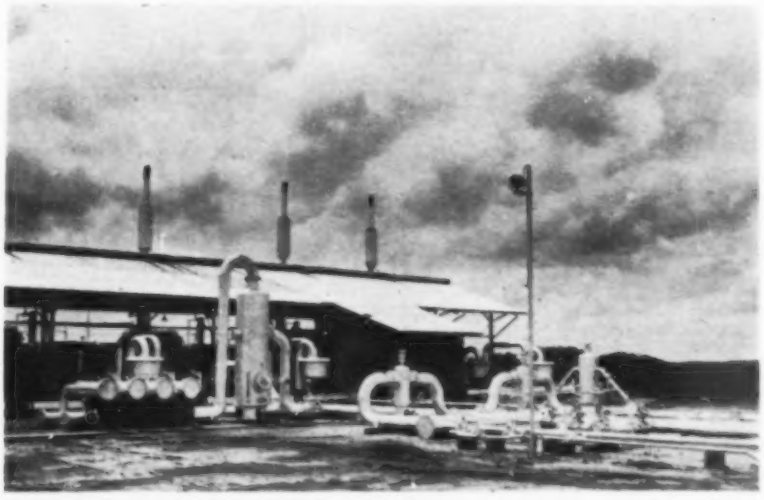

FIG. 10. Suction manifold at main compressor station.

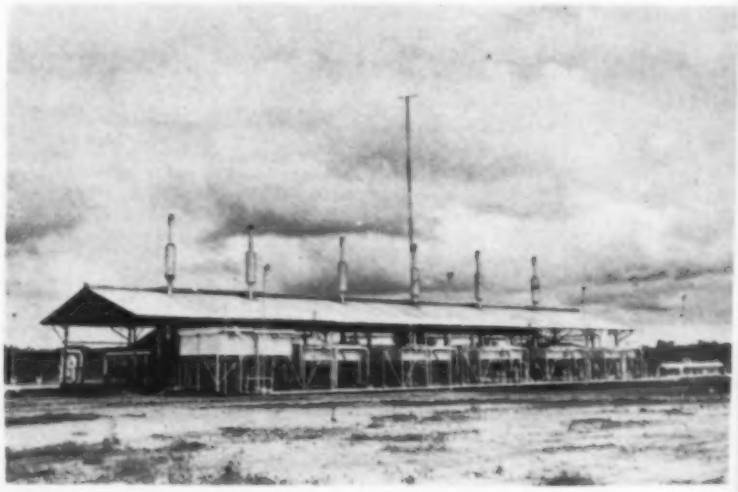

FIG. 11. View of main compressor station from the rear.

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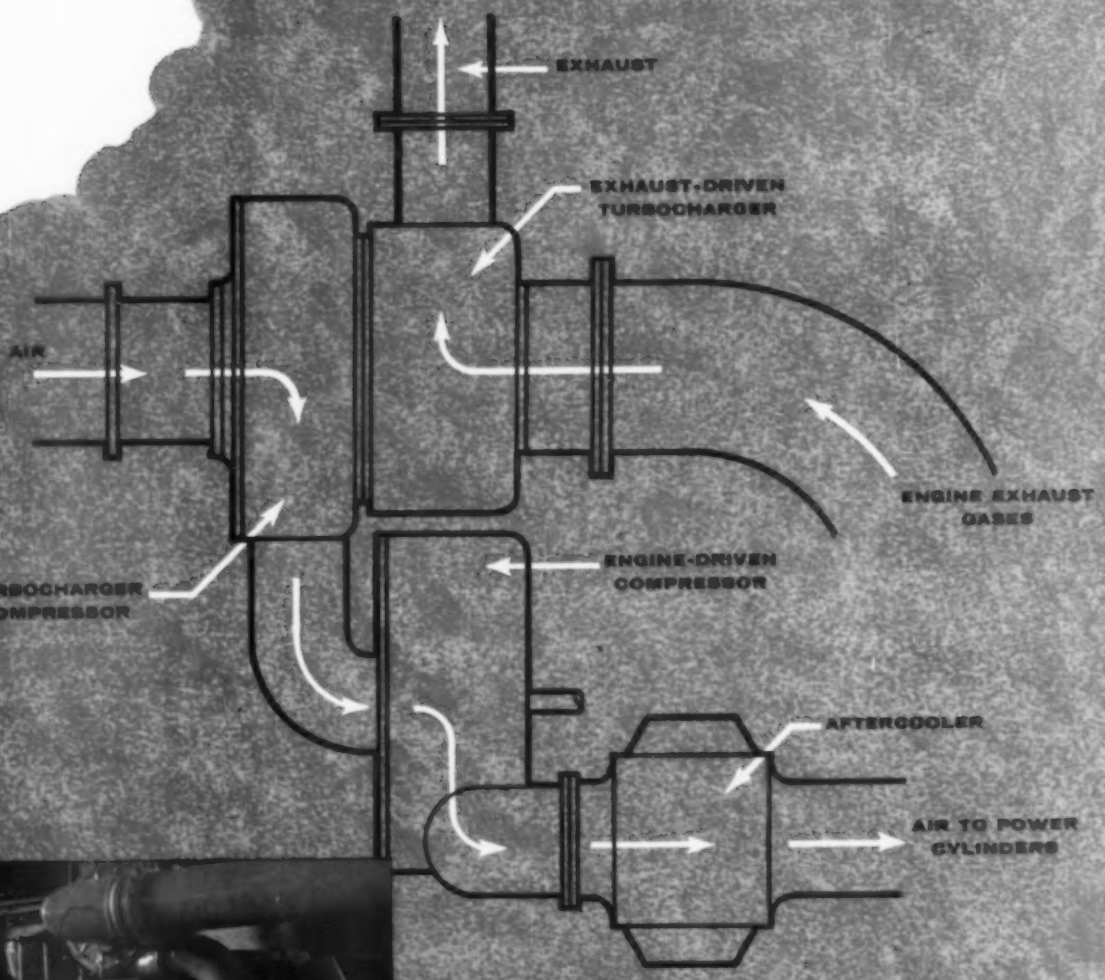

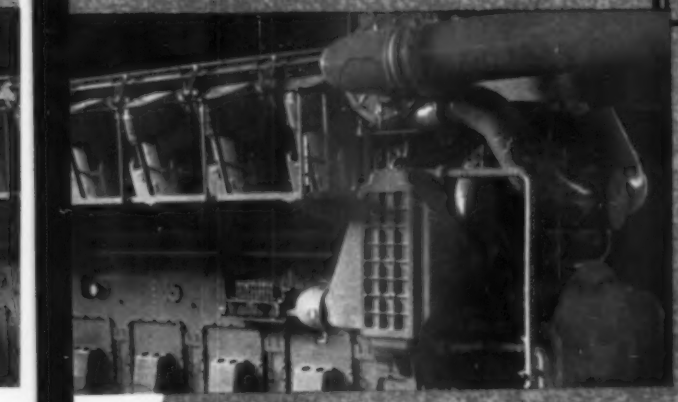

Operational Diagram of Cooper-Bessemer Series Turbocharging

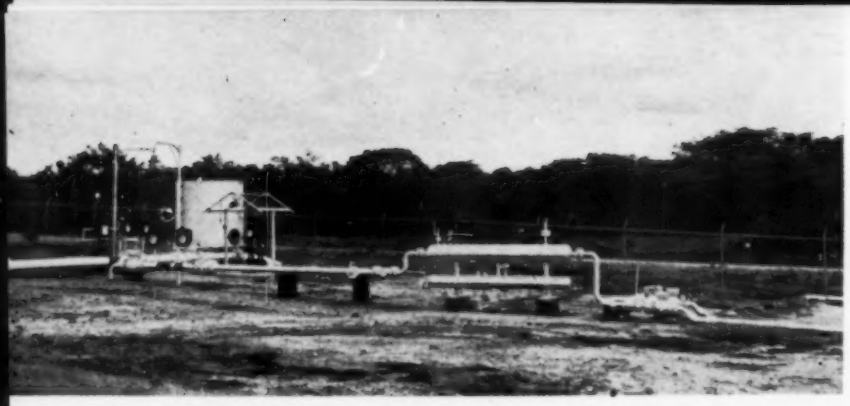

FIG. 12. Inlet point for high-pressure well gas downstream of main compressor station. At left are main station discharge and two paymeters.

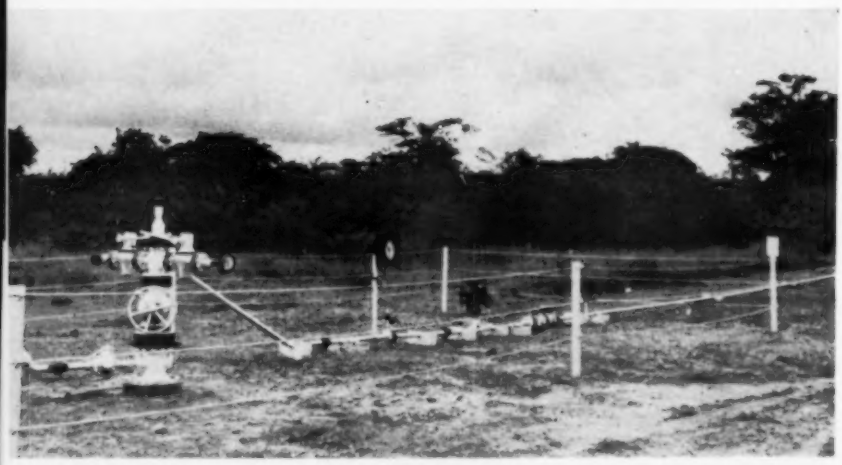

FIG. 13. High-pressure gas well, showing orifice meter and pilot-controlled valve.

ured at the well head, with a separate meter for each zone.

Automation

Battery compressors, which are unattended except for daily checks, have automatic shut-downs for low oil pressure, overspeed, high water temperature, and high liquid level on the intake gas scrubber. All gas wells are remote-controlled from either the main compressor station, the Lechoso dehydration plant, or entrance points along the 12-in. Lechoso trunk line. Upon manually opening or closing the valve at the entrance point, the change of line pressure actuates the pilot control valves at the well heads. High-low shut-off devices in these pilot valves protect the wells in case of an undetected line break.

Compressor Maintenance

Preventive maintenance schedules for all compressors call for 3000-hr inspections to include oil change, cleaning of engine cylinder ports, inspection of one engine piston and overhaul of the compressor end. A complete inspection and maintenance of engine and compressor end is performed once a year.

Demand Variations and Conservation

The bulk of the SAPLM gas is used by the Electricidad de Caracas thermoelectric plant at La Guaira and by industries that operate 8 or 16 hours a day, five days a week. Thus, demands on the SAPLM system vary widely, with daily early evening highs and with week-end lows. These variations are accommodated by turning the high-pressure gas wells in and out of the system; this is normally handled by the operators at the main compressor station or at the Lechoso dehydration plant.

Since there are no stand-by compressors in the system, every effort is made to keep all available compressors, both at the batteries and at the main station, onstream and fully loaded. When demand is low, or when main station compressors are down for repairs or maintenance, intermediate pressure gas wells are shut-in. In this manner, the flaring of gas anywhere in the system, and the use of high-pressure reserves for make-up gas, are minimized. Maximum conservation is attained by full use of radio communications and by constant coordination between maintenance and operating personnel.

Sales

Gas sales have been geared to the rising demand for natural gas in Caracas and Central Venezuela. Average daily sales, in million standard cubic feet per day, have been as follows:

Year		Avg MM Ft³/Day
1952	(Jul.-Dec.)	8
1953		22
1954		28
1955		41
1956		48
1957	(Jan.-Jul.)	56

Acknowledgments

The author is indebted to the management of Sociedad Anonima Petrolera Las Mercedes for permission to publish this article and to G. A. Savary, T. G. McAllister, and V. E. Harless for help in the preparation of the article.

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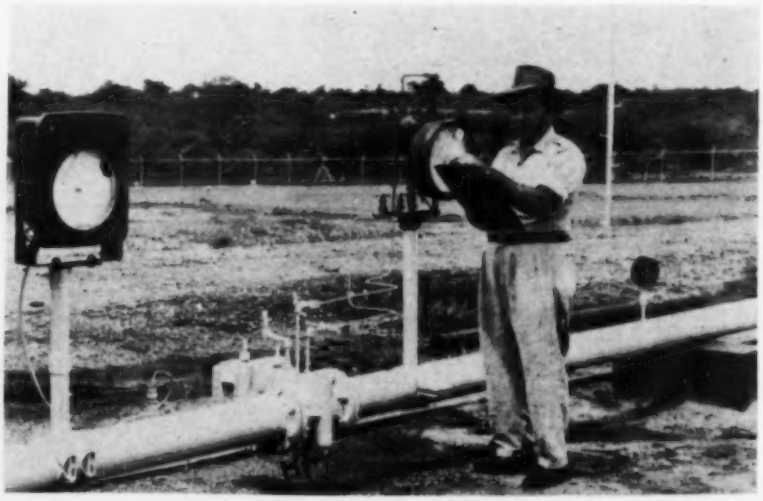

FIG. 14. Main compressor station operator on his hourly check of an orifice meter.

P 615.11

W. E. Brigham, E. D. Holstein, and R. L. Huntington

University of Oklahoma

Two-Phase Concurrent Flow of Liquids and Air Through Inclined Pipe

The research project reported in this paper was undertaken for the purpose of studying the effect of up and down-hill flow on pressure drop. Recent field results show that excessive pressure drops have been encountered in two-phase pipelines through hilly country

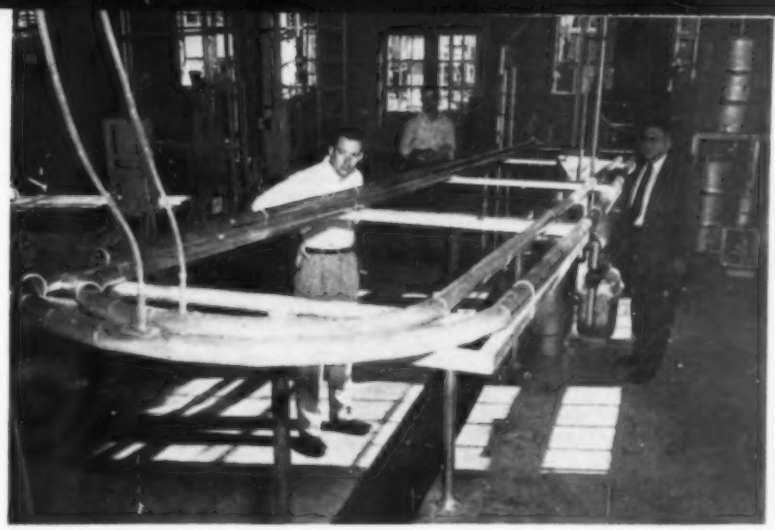

FIG. 1. Apparatus used in experimental work.

THE CHARACTERISTICS of single-phase fluid dynamics have been studied both experimentally and theoretically by Reynolds, von Karman, Prandtl and many others; and accurate predictions of frictional loss can be made from the relationships developed by these investigators. However, attempts at analysis of simultaneous concurrent liquid and gas flow have been largely empirical in nature.

Certain semi-quantitative aspects of a two-phase flow system can be readily understood. For instance, Baker[2] has pointed out that when both fluids flow simultaneously through the same pipe, the cross-sectional open area for either fluid is reduced, thus decreasing the effective diameter of the pipe. In single-phase flow, frictional loss is inversely proportional to the fifth power of the diameter. To illustrate this marked effect, a reduction of only 20 percent in effective diameter will cause the pressure drop to triple for a constant mass-flow rate. Again, in certain types of flow the liquid-gas interface is uneven. Many investigators have compared this interfacial turbulence to wall roughness in pipes and have explained the excessive two-phase pressure drops in this way.

The difficulty of trying to measure such variables as interfacial height, velocity gradients, and shear stress have made it extremely difficult to use an experimental approach based on theoretical considerations. Thus, the emphasis has been given to development of empirical correlations.

Paper abstracted from an MS thesis by W. E. Brigham and E. D. Holstein. R. L. Huntington is research professor, School of Chemical Engineering, University of Oklahoma, Norman. Paper presented at ASME Petroleum Mechanical Engineering Conference, Tulsa, Oklahoma, September 22-25, 1957.

A notable exception is the work of Bergelin[3] and Gazley.[5] They studied the energy transfer at the common interface, and velocity gradients in the stratified flow region. However, this type of flow is extremely limited in scope since it occurs only at very low gas and liquid rates in short horizontal and down-slope sections and does not occur at all in up-slope flow.

Martinelli, et al[9] developed one of the first empirical correlations in 1944. The correlation was extended and revised in 1946[10] and 1949[8] by Martinelli and others with the following four possible flow types:

1. The gas and liquid are both in laminar flow.
2. The gas flow is laminar while the liquid flow is turbulent.
3. The gas flow is turbulent while the liquid flow is laminar.
4. The gas and liquid are both in turbulent flow.

The correlation involves the use of an experimentally determined variable Φ where:

$$\Phi^2 = \frac{\Delta P_{TP}}{\Delta P_g}$$

ΔP_{TP} is the actual two-phase pressure drop and ΔP_g is the pressure drop that would be found if the gas were flowing alone. Φ is plotted as a function of X where:

$$X^2 = \frac{\Delta P_l}{\Delta P_g}$$

ΔP_l is the pressure drop that would be encountered if the liquid were flowing alone and similarly ΔP_g for the gas. Martinelli et al correlated their data within an accuracy of +20 and −30 percent by plotting Φ vs X. However, since the two-phase pressure drop is assumed to be proportional to Φ^2 in this correlation, the data are actually within only +44 and −50 percent. Bergelin and Gazley[6] found that this correlation gives separate lines for each liquid rate, indicating that there was a banding of data rather than a good correlation. The data presented here also show a banding of points as seen in Fig. 4. It also has been found in this investigation and by others[2,6] that there is a sharp change of slope when a constant liquid-rate line is plotted on Φ^2 vs X^2 co-ordinates. This change of slope corresponds to the transition region between two visually observed flow patterns such as slug to

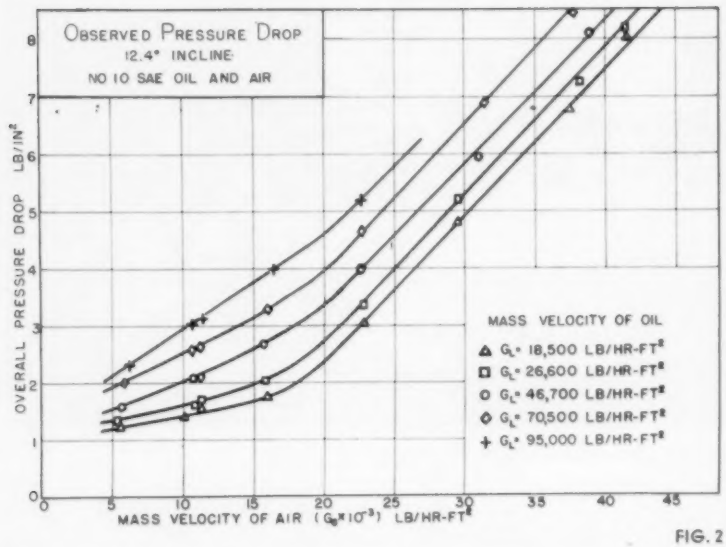
OBSERVED PRESSURE DROP
12.4° INCLINE
NO 10 SAE OIL AND AIR
OVERALL PRESSURE DROP LB/IN²
MASS VELOCITY OF AIR (G_g×10⁻³) LB/HR-FT²
MASS VELOCITY OF OIL
△ G_L= 18,500 LB/HR-FT²
□ G_L= 26,600 LB/HR-FT²
○ G_L= 46,700 LB/HR-FT²
◇ G_L= 70,500 LB/HR-FT²
+ G_L= 95,000 LB/HR-FT²

FIG. 2

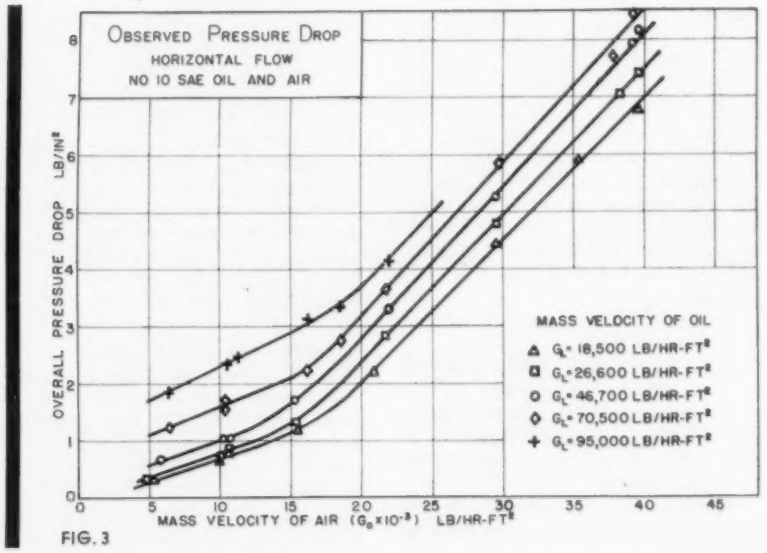
OBSERVED PRESSURE DROP
HORIZONTAL FLOW
NO 10 SAE OIL AND AIR
OVERALL PRESSURE DROP LB/IN²
MASS VELOCITY OF AIR (G_g×10⁻³) LB/HR-FT²
MASS VELOCITY OF OIL
△ G_L= 18,500 LB/HR-FT²
□ G_L=26,600 LB/HR-FT²
○ G_L= 46,700 LB/HR-FT²
◇ G_L= 70,500 LB/HR-FT²
+ G_L= 95,000 LB/HR-FT²

FIG. 3

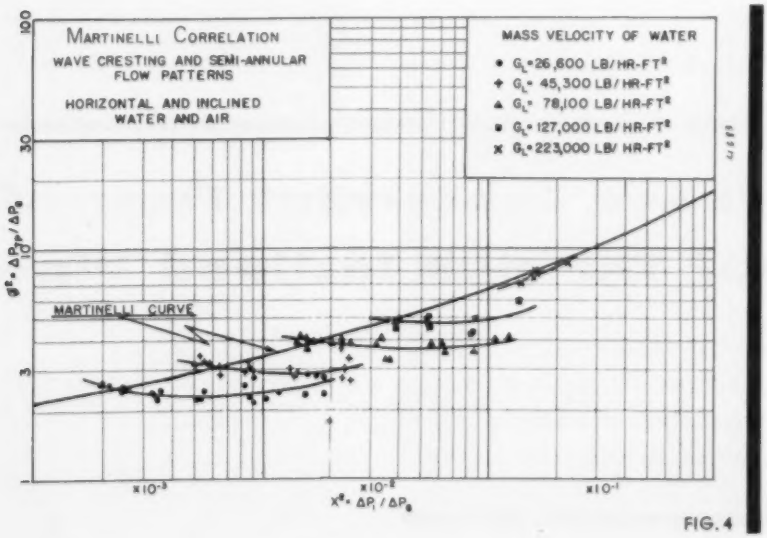

FIG. 4

wave of slug to semi-annular. Thus it seems that an all-inclusive correlation based on the usual Reynolds number criterion between laminar and turbulent flow should not be used, but rather that the flow patterns should be treated separately.

White, et al[12] have presented a correlation for two-phase flow in the region of wave, cresting and semi-annular flow patterns. Other investigators [1,2] have classified this region as annular flow. White's correlation is based on a psuedo friction factor (f_w) and a flow ratio Φ_w, where the terms are given by the following equations:

$$f_w = \frac{2\, g_c\, D_6\, \rho_l}{W_l^{3.6}} \left(\frac{\Delta P}{L}\right) \frac{}{W_l + W_g}$$

$$\Phi_w = \left(\frac{G_l}{G_g}\right)^{1.8} \left(\frac{\rho_g}{\rho_l}\right)^{0.9} \left(\frac{1}{\mu_g\, \mu_l}\right)^{0.1}$$

White was able to correlate his own data within ±18 percent as well as those of Schneider,[11] Jenkins,[7] and Martinelli.[8] It appears that White's correlation is limited to the pressures and temperatures studied since its development is entirely empirical. Chenoweth, et al[4] have revised and improved Martinelli's correlations for high pressure but basically at low pressures their correlation is similar to Martinelli's.

Experimental Equipment

The apparatus consisted of a double loop of 1.975-in. ID clear plastic (Tenite) tubing mounted on an angle-iron frame that could be adjusted to various inclines. Orifice and displacement meters, pressure gages, U-tube manometers, and thermometers were used to measure the flow variables. A photograph of the apparatus is shown in Fig. 1. The overall length of the test loop was 27 ft and there were 97 ft 2 in. of straight pipe in the test section. The equivalent length of the test section including bends was found to be 124.5 ft.

As the pressure surges were very great with slug flow it was necessary to install buffers in the manometer lines to make readings more stable. The buffers consisted of small surge tanks with the inlet and outlet leads packed with steel wool. The packing technique was difficult to develop because the packing had to be tight enough to lessen the pressure surges but not tight enough to impair the true manometer reading.

Data were taken using No. 10 SAE lubricating oil or water as the liquid phase and air as the gas phase. The density of the No. 10 SAE oil at 83 F was 53.9 lb per cu ft and its viscosity was 70.4 lb per ft-hr. During the experimental runs the maximum range of temperature was not enough to affect

appreciably the density or viscosity of either the oil or the water. The slopes used were 12.4 deg, 5.5 deg and horizontal.

Experimental Results

The flow patterns found were similar to those reported by White and other investigators; however, there was one notable exception. The region of stratified flow as recorded by Alves, White, Bergelin, Gazley, and many others did not exist even in horizontal flow. Stratified flow involves a pattern that is characterized by a change in interfacial height along the length of the pipe. A logical conclusion that can be drawn is that if there is any irregularity in a pipe, such as a bend or slight dip, stratified flow will not exist at all and the flow at low gas rates will be slug type. The results of this investigation bear out this conclusion.

Nomenclature

The following nomenclature is used in the paper:

- D = diameter, ft
- f_w = White's pseudo-friction factor
$$f_w = \frac{2g_c D \rho_l}{W_l^{1.8} + W_g} \left(\frac{\Delta P}{L}\right)$$
- G = mass velocity, based on total cross-sectional area, lb/hr-ft²
- g_c = conversion factor in Newton's laws of motion, (ft) (lb mass)/(lb force) (hr²)
- L = equivalent length of pipe, ft
- ΔP = pressure drop, lb/ft²
- W = mass rate of flow, lb/hr
- X = Martinelli's flow modulus, dimensionless
- ρ = density, pcf
- Φ_w = White's flow ratio,
$$\Phi_w = \left(\frac{G_l}{G_g}\right)^{1.8} \left(\frac{\rho_g}{\rho_l}\right)^{1.0} \left(\frac{1}{\mu_g\ \mu_l}\right)^{0.1}$$
- Φ = Martinelli's flow parameter based on gas-phase pressure drop for turbulent-turbulent flow, dimensionless
- μ = viscosity, lb/ft-hr

Subscripts

- g = gas-phase characteristics
- l = liquid phase characteristics
- TP = two-phase characteristics
- w = refers to White's correlation

Fig. 2 and 3, respectively, show typical pressure-drop data for oil and air at the 12.4 deg slope and the horizontal position. The plots show overall pressure drop versus air-mass rate in pounds per hour per square foot of open cross-sectional area. The parameters are liquid mass rate in the same units. As might be expected, the pressure drop is proportional to the mass rate of either phase. In general, the mass rate of the gas has a greater influence on pressure drop than has the mass rate of the liquid.

It is interesting to note that there is a change in the flow pattern whenever the air rate exceeds approximately 16,000 lb per hr-sq ft. On both graphs there is a definite change in slope that corresponds to this change in flow type. It is also of interest to note that at the lower air rates, the pressure drop is much greater at the 12.4 deg incline than at the same rate in horizontal flow — greater by as much as three to four times. As the inlet and outlet pressure taps for the test loop were at the same level, this inequality cannot be due to a change in head, but can only be a result of the irreversible losses in slug-type flow.

In single-phase flow the potential energy head at the top of a rise is regained as pressure energy as the fluid flows down hill, but in two-phase flow the flow pattern changes from slug on the up-hill side to stratified on the down-hill side and the potential energy is not regained. However, once a steady flow pattern with little pressure fluctuation such as wave, cresting or semi-annular is reached, the pressure drops at horizontal and at an incline are identical. These regions are shown in Fig. 2 and 3 at the higher gas rates.

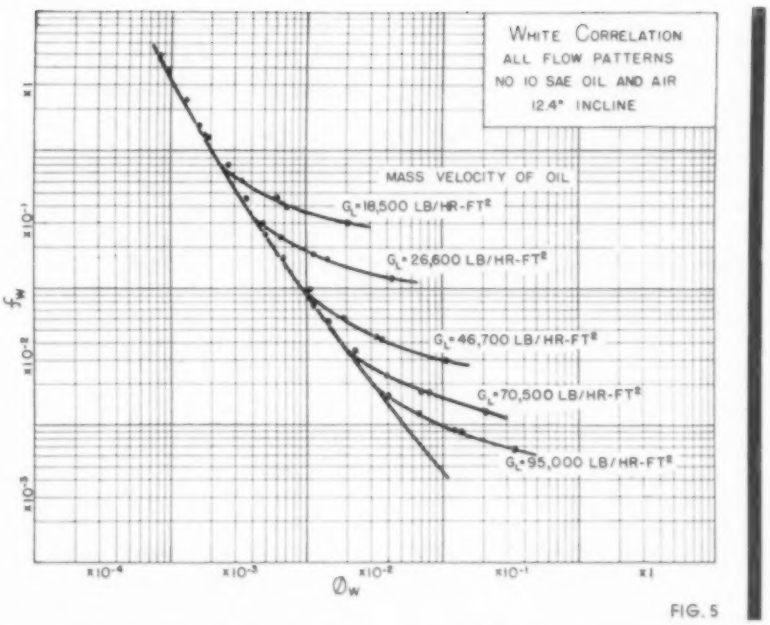

FIG. 5

Martinelli Correlation

The water-air data for all slopes are plotted in Fig. 4 using Martinelli's parameters. The oil-air data would appear very similar on this type of plot. This plot of X^2 vs Φ^2 shows more clearly the reliability of the correla-

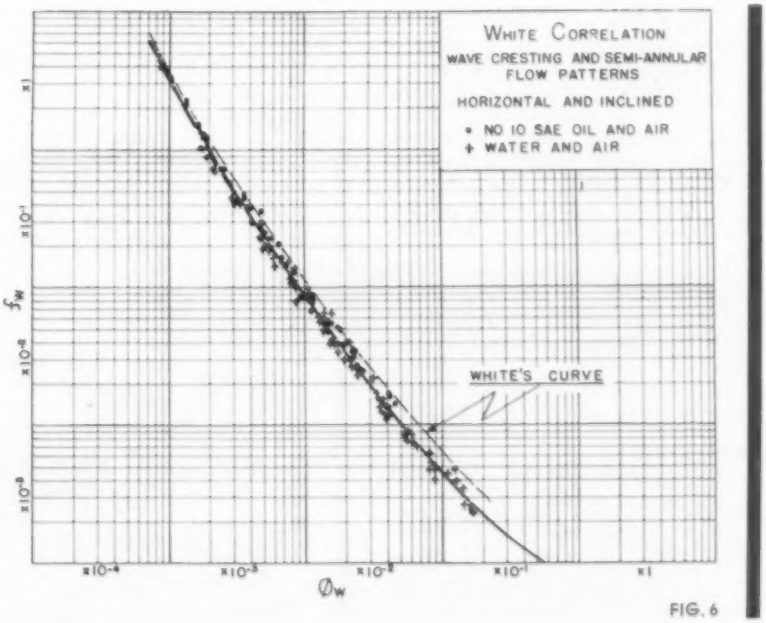

FIG. 6

tion. Slug and ripple flow are not included because pressure drop in this region is a function of the slope and will not correlate on this plot. Slug flow points merely extend these lines upward to the right at a sharp angle. In fact, at the 12.4-deg slope some recorded pressure drops in the slug flow region are five to six times as great as predicted by the correlation.

White Correlation

Fig. 5 shows the White correlation for oil and air at the 12.4 deg slope. Each separate line is at a constant liquid rate. The transition of flow type is clearly defined. In the region of wave, cresting and semi-annular flow, the data fall on the correlation, but as the gas rate is reduced, the pattern changes to slug flow and the pressure drops are much greater than the correlation predicts.

Since wave, cresting, and semi-annular flow data exhibit the same pressure drop at all slopes, these data were included in Fig. 6 for both the oil-air system and the water-air system. The maximum error for these 155 points is 35 percent. There is no banding of the data as in the Martinelli correlation. It appears that this correlation is definitely valid at these low pressures for flow at any angle. This method is entirely empirical, however, and is not likely to be correct at high pressures. The most important consideration here is that the angle of slope definitely does not affect overall pressure drop when the fluids are flowing in wave, cresting or semi-annular flow. Co-ordinates for the White correlation are given in Table 1.

TABLE 1. Cooordinates for White Correlation Fig. 6.

f_w	Φ_w
6.0	7.1×10^{-4}
3.0	1.04×10^{-3}
1.0	1.95×10^{-3}
6.0×10^{-1}	2.70×10^{-3}
3.0×10^{-1}	4.3×10^{-3}
1.0×10^{-1}	8.9×10^{-3}
6.0×10^{-2}	1.33×10^{-2}
3.0×10^{-2}	2.22×10^{-2}
1.0×10^{-2}	5.1×10^{-2}
6.0×10^{-3}	7.8×10^{-2}
3.0×10^{-3}	1.48×10^{-1}
1.0×10^{-2}	7.1×10^{-4}

Acknowledgment

The authors are deeply indebted to the Gulf Oil Corporation, Phillips Petroleum Company, and the Celanese Corporation, which sponsored fellowships in connection with this research.

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COMMENT

By Ovid Baker
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Dallas, Texas

This paper makes possible practical design calculations for two-phase pipelines. There are many articles in the literature giving the pressure drop of liquid and gas mixtures in horizontal pipelines, but it is difficult to find an oil field that does not have hills and valleys in it. Up to this time practically no research work has been done on a method for taking into account the increased pressure drop caused by the hills. Sometimes hills in the line cause 10 times the pressure drop calculated for horizontal flow only.

The authors have demonstrated that hills do not increase the pressure drop much except at low gas flow rates. This has been the experience of the operators of gas gathering lines in the summertime when gas demand is low and gas flows are reduced. Small quantities of oil produced with the gas, which under ordinary conditions flow on into the plant, begin to accumulate in the valleys and the pressure drop increases. When gas flows begin to increase with colder weather, this oil usually comes into the plant in big slugs, sometimes straining the plant's facilities to handle it.

The approach Magnolia has used in evaluating the effect of hills on two-phase pressure drop has been to add an increment of pressure drop caused by hills to the pressure drop we normally expected in a horizontal line.

Equation 1 shows the procedure we have used for evaluating the two-phase pressure drop in hilly terrain.

$$\Delta P_{tph} = \Delta P_{tp} \text{ (for horizontal pipe)} + \frac{NHF_e\rho_L}{144} \quad . \quad . \quad . \quad (1)$$

ΔP_{tp} = Calculated two-phase pressure drop for horizontal pipe, psi

ΔP_{tph} = Calculated two-phase pressure drop for pipelines in hilly terrain, psi

N = Number of hills

H = Average height of hills in feet

F_e = Elevation factor from chart or $F_e = \frac{1.61}{V^{0.7}}$

ρ_L = Density of liquid flowing in line, lb/cu ft

V = Gas velocity in pipeline, ft/sec (Based on 100% Pipe Area)

In Magnolia's original paper on two-phase flow we suggested adding a liquid head equal to one-half the height of the hill to the pressure drop calculated by the horizontal flow equation, or $F_e = 0.5$. This head should be added for each hill the line goes over.

We looked at this problem as though

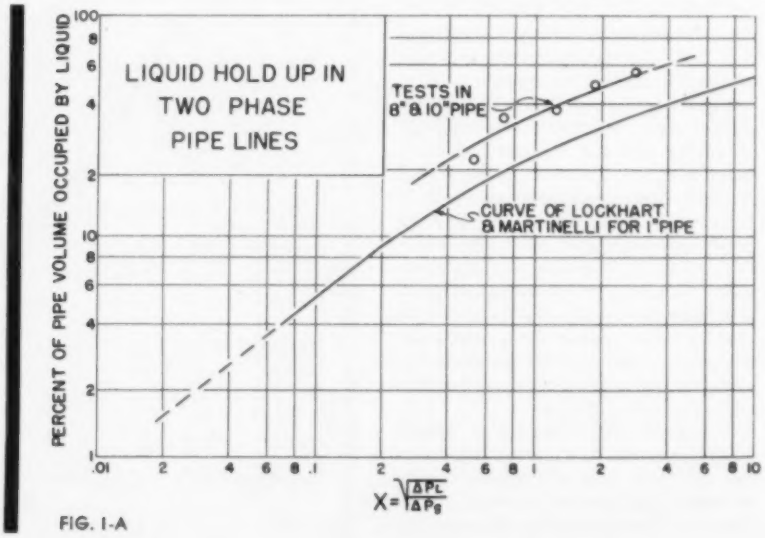

FIG. 1-A

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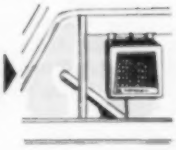

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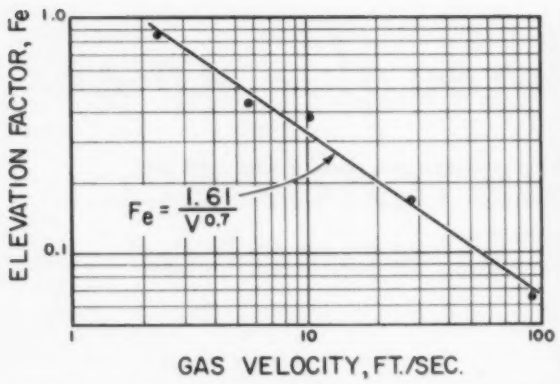


FIG. 2-A

TABLE 3. Typical Gas Velocities in Two-Phase Pipelines.

	Psig	Bbl oil per MMcf	Gas velocity ft/sec
Black oil system	400	2000	0.5–5
Casinghead gas gathering	15	0.1–0.001	2–35
Distillate well stream gathering	1000	20	2–14
Distillate well stream gathering	1600	25	4–13
Distillate well stream gathering	3300	350	1–3

TABLE 1. Amount of Oil Holdup Expressed as Percent of Hill Height when Flowing in a Froth Pattern in a 6-in. Line in Hilly Country.

Length of line ft	Gas velocity ft/sec	Gas velocity miles/hr	Percent of hill height	K*	Pressure psia	Total height of hills, ft	No. of hills	Diam., in.
100,790	1.5	1.02	79.5	1.06	469	982	40	6
"	2.0	1.36	60.6	0.99	427	"	"	"
"	2.04	1.39	74.7	1.23	309	"	"	"
"	2.4	1.63	70.0	1.29	279	"	"	"
"	3.0	2.04	50.7	1.09	313	"	"	"
"	4.25	2.89	44.3	1.22	173	"	"	"
"	4.75	3.23	34.1	1.02	195	"	"	"
"	6.7	4.56	31.0	1.17	146	"	"	"
			Average	1.13				

*Fraction of hill height $= \frac{K}{V^{0.7}}$
V = ft/sec

the gas was having to bubble through a series of manometers. The "holdup" or the amount of liquid in the manometers was the important thing to know. Fig. 1-A shows "holdup" relationship for horizontal pipe. The holdup is a function of the calculated pressure drops of the liquid and the gas, assuming each phase flowed in the line alone. Other conditions remaining constant, an increase in gas velocity lowers X and reduces holdup. An increase in liquid flow rate increases X and increases holdup.

It is all very well to know these things qualitatively, but data on inclined flow "holdup" and F_e factors is necessary before a line can be designed with confidence.

Several years ago we obtained some data from another company on froth flow in 6-in. pipeline in hilly country. Calculation of some of their froth flow experimental data indicated that with this flow pattern the pressure drop could be correctly predicted by using the froth flow equation given in the article "Simultaneous Flow of Oil and Gas in Pipelines," (*Oil and Gas Jour.*, July 26, 1954). Although there was a total elevation of 982 ft as the line passed over some 40 hills, there was no effect on the pressure drop due to the hills. The line was flowing a mixture of oil and gas and, as a part of the experiment, valves were closed simultaneously at each end of the line. Static pressure was then measured between the inlet and outlet of the line, which gave an indication of the amount of liquid holdup in the line. This amount of liquid holdup can be related to the velocity of the gas flowing in the line by the formula:

$$F_e = \frac{K}{V^{0.7}}$$

TABLE 2. Gas Velocity Versus Static Liquid Head as a Percent of Total Hill Height for Two-Phase Pressure Drop.

Length of line ft	Gas velocity ft/sec	Gas velocity miles/hr	Percent of hill height	K*	Pressure psia	Total height of hills, ft	No. of hills	Diam., in.
4,400	2.32	1.59	84.5	1.52	425	110	1	4
132,000	5.26	3.58	43.5	1.39	750	2,430	36	16
25,442	10.2	6.8	38.0	1.92	1550	262	6	6
120	28	19.0	16.7	1.72	14.7	12	2	2
120	92	62.6	6.4	1.51	14.7	12	2	2
			Average	1.61				

*Fraction of hill height $= \frac{K}{V^{0.7}}$
V = ft/sec

Where:
F_e = Fraction of total hill height as liquid head
K = A constant
V = Velocity of gas, ft/sec

The average value of 1.13 was obtained for K.

These data lead us to guess that the flow pattern going uphill is froth flow whether or not the horizontal sections of the line are in froth flow. Studies by University of Oklahoma indicate that the uphill flow is very often slug flow whereas stratified or wave flow occurs on the downhill side.

The authors have covered a gas velocity range from 12 to 80 ft per sec. Some of Magnolia's two-phase gathering lines have lower velocities than these. Table 3 shows gas velocities calculated from operating data on some typical gathering systems.

As a result of the data showing that the liquid holdup in the line was a function of the gas velocity we applied this same idea to a few data from some field tests to determine whether velocity would make any difference in the inclined flow correction where we do not have froth flow. These data are shown in Fig. 2-A. They include two of Brigham's points, two points from our original paper, and a third obtained recently. Although these data were taken under field conditions and may not be reliable, they result in a very suggestive relationship. The same formula, as shown above, for expressing line holdup in froth flow can be used to predict the height of static liquid head to be added to the calculated two-phase pressure drop for horizontal lines. The only change required is that the constant K would be made equal to 1.61. This relationship is shown in Fig. 2-A.

Brigham's data for a liquid mass velocity of 18,000 fall slightly below and parallel to the line shown in Fig. 2-A. His data for a liquid mass velocity of 70,000 fall higher and parallel. Apparently a four-fold increase in liquid mass velocity causes a two-fold increase in F_e. His data suggest that the relationship shown in Fig. 2-A is too simple. A more comprehensive relationship will need to be developed for low gas velocities by further research and experience. ★ ★ ★

Canadian News Notes

Westspur throughput increases. A major switch in supply sources of crude oil for Ontario refineries is producing rapid increases in throughput for Westspur Pipe Line Company, which serves the entire light oil producing region of Southeastern Saskatchewan with its dual 12-in. and 16-in. lines. For September Westspur estimates its traffic volume at 59,500 bbl per day average, an increase of 2672 bbl per day from August to set a new all-time record for the second month in a row. A significant switch for September was the shipment of more than 14,000 bbl per day to the Canadian Oil Companies, Ltd., refinery in Sarnia, Ontario, due to the rising interest of Canadian oil in Saskatchewan production from the Weyburn and Halbrite fields.

Westspur now has complete segregation in its system east of Steelman, with the 12-in. line carrying exclusively medium gravity crude from the fields at the western end of the system and the 16-in. loop from Steelman to the Cromer terminus carrying only light crude from the central and eastern fields.

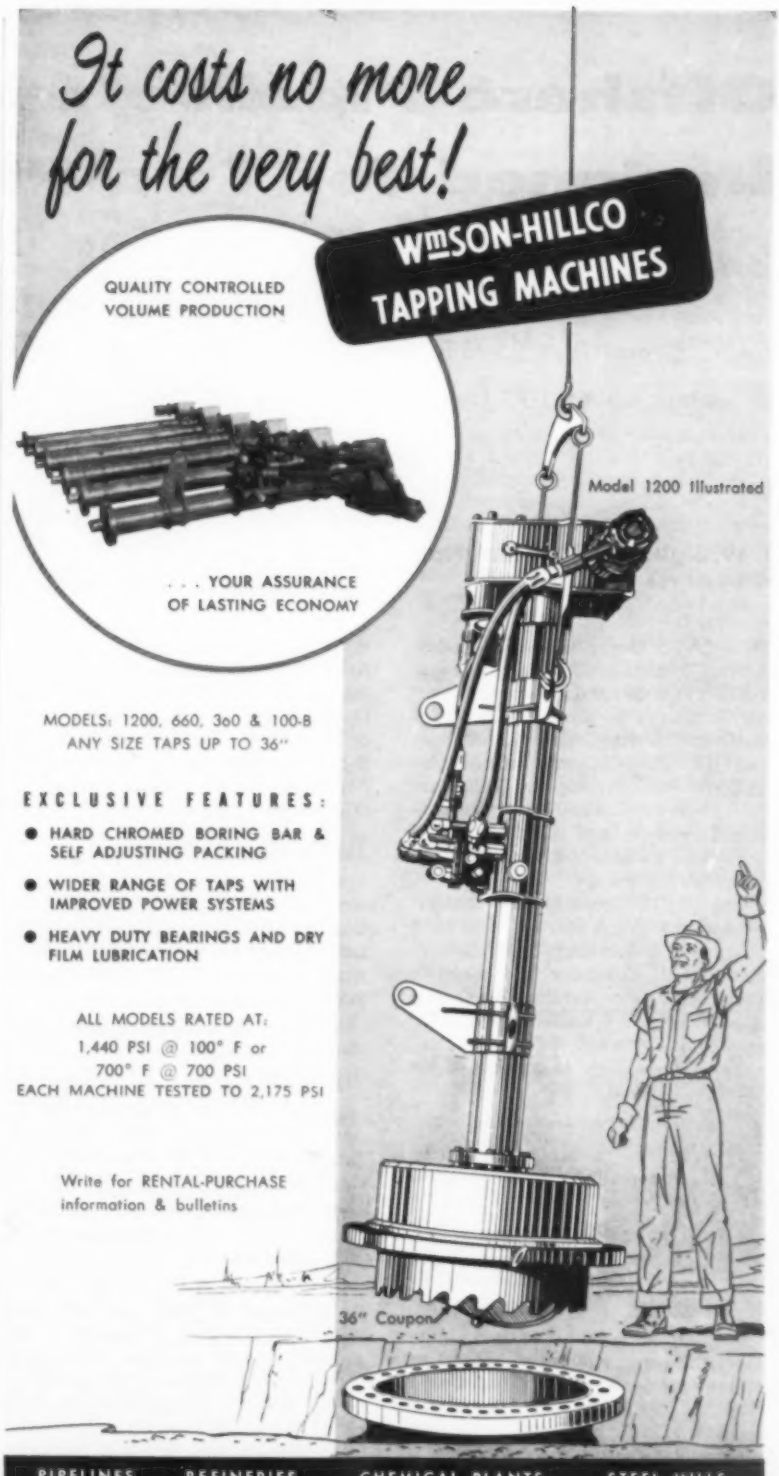
Westspur estimates growth of its traffic at 3000 bbl per day per month or better for the next few months.

Lakeland Natural Gas, Ltd., subsidiary of Great Northern Gas Utilities, Ltd., Edmonton, and operating entirely in eastern Ontario, has work underway for the 19 cities and towns for which it has been granted franchises for natural gas service. Supply will come from the Trans-Canada pipeline.

Lakeland has received more than 1,000,000 ft of pipe for the 1957 construction program, which represents a large part of the mains and services required in the franchised areas.

Engineering plans are completed, most of the right-of-way acquired, and the large yard-coating contract has been awarded to F. E. Shaw, Ltd., of Sarnia.

Interprovincial completes extension. Interprovincial Pipe Line Company has completed its 156-mile, 20-in. extension from Sarnia to Toronto, making total main line mileage now 1931 miles. Deliveries started to the British American refinery at Clarkson on October 1, with deliveries to Regent Refining (Canada), Ltd., at Port Credit on November 1.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Offshore Pipeline System Designed for Two-Phase Flow

CATC Group lays 25-mile line in waters up to 100 ft in depth

T. W. Sigler and W. L. McNatt
Continental Pipe Line Company

THE CATC Group in October, completed a 25-mile undersea pipeline system that extends from a point on Grand Isle, Louisiana, to three self-contained platforms in the Grand Isle offshore area. The CATC Group includes Atlantic Refining Company, Tidewater Oil Company, Cities Service Production Company, and Continental Oil Company. Conoco serves as the operator for the group.

The pipeline construction contract was awarded to Marine Gathering Company, a subsidiary of Commonwealth Oil Company of Houston, Texas, and the terminal was constructed by Ward Construction Company of San Antonio, Texas.

The system (Fig. 1) consists of the following:

1. **A terminal on Grand Isle.**
2. **A 12-in. main line from the central platform in Block 47 to Grand Isle.**
3. **Six-in. and 8-in. gathering lines from outlying platforms to the central platform in Block 47 (Fig. 2).**

The terminal at Grand Isle is equipped with treating equipment, separating equipment, liquid storage tanks, and barge loading facilities. As production develops at other platforms in the area, additional gathering lines will be laid into the central platform in Block 47.

Continental Pipe Line Company, a subsidiary of Continental Oil Company, handled the design and construction of the pipeline and terminal facilities.

The pipeline system was designed for two-phase (simultaneous gas and liquid) flow. Separation and measurement occur at the onshore terminal from which point gas is delivered to a gas carrier with the liquids being delivered to a crude oil pipeline or loaded on the barges. The design capacity of the 12-in. main line is approximately 31,000 bbl per day of liquids and 46,000,000 cu ft per day of gas.

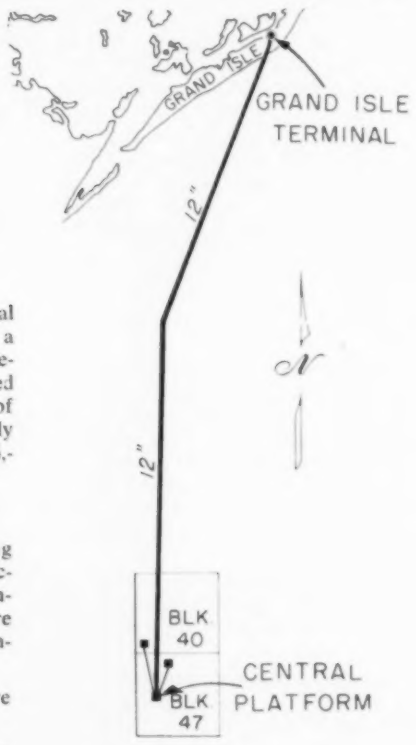


FIG. 1. **From a central platform** in Block 47 a 12-in. line brings oil and gas ashore to a terminal on Grand Isle.

Justification of Pipeline

In initial discussions concerning movement of gas and liquid production from this area to markets, a number of problems were revealed. There were three possible solutions to consider in this particular area:

1. Continue barging liquids ashore as produced.
2. Continue barging production ashore with tankage (either on platforms or submerged) being constructed to accumulate production during bad weather.
3. Construct pipeline or pipelines to move production ashore as produced.

In both of the first two cases, it would be necessary to flare gas associated with liquids that were produced. Although they did not offer a complete solution to the problems, the economics of a pipeline was determined as compared to both of these alternates.

Experience had indicated that only about 45 percent of allowable production could be accomplished with barge movement and with no offshore tankage. Virtually 100 percent of allowable production could be achieved with the construction of approximately 10 days storage offshore. Therefore, it was necessary to determine the optimum amount of offshore storage to con-

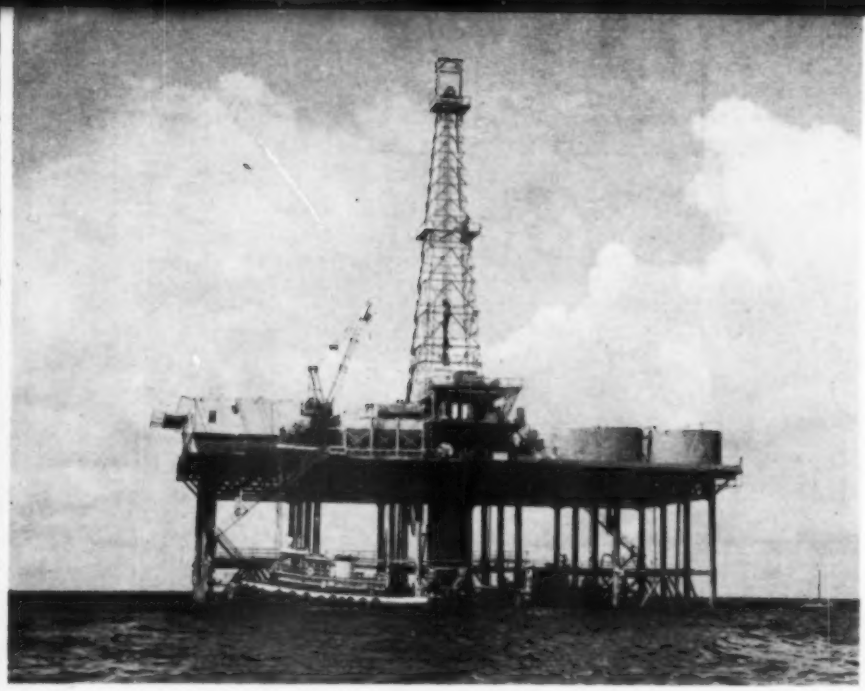


FIG. 2. Central platform, Grand Isle Block 47.

struct if barging was to be continued. This then was compared with the pipeline to show its economic justification.

The additional investment required for the pipeline above that required for offshore storage was justified through savings in barging costs, operating expense, and the cost associated with deferring production.

Preliminary Survey

A number of problems in design of the line were foreseen, which would necessitate a preliminary survey to include a profile of the ocean floor along the pipeline route and an analysis of the soil encountered on the ocean floor. Some of these problems were:

1. Would channels or valleys be encountered that would result in unsupported spans?
2. Would reefs or other conditions be encountered that would result in unusual construction problems?
3. Would any marine life be encountered to necessitate such protective measures for the pipeline?
4. What would be the density of the Gulf floor at various depths?

Seas Engineering and Salvage Company of Houston, Texas, was engaged to make a survey to include a bottom profile and soil analysis. It was necessary to "stake" the pipeline route within fairly close limits, and it was also necessary to utilize methods such that this routing could be reproduced at the time of construction.

The pipeline route was marked by buoys, using an electronics survey method by Raydist, Inc. This method reflects three shoreline transmitter stations and one mobile receiving station on a boat with the mobile station (boat) being directed to predetermined coordinates by the shoreline stations. The advocates of this survey method guarantee an accuracy of plus or minus 25 ft, which was adequate.

Twelve-foot cores were taken at 1500-ft intervals along the pipeline route. These cores were taken by a gravity drop coring device and were transported to a core lab for analysis. Information obtained from the cores was supplemented by stratograph runs over the entire pipeline route.

The stratograph is an instrument that reveals the existence of dense or hard sub-bottom stratas. The primary purpose for employing this device was to locate buried shell reefs that might be encountered and also to determine the existence of Beaumont clay stratas. Beaumont clay stratas have been encountered in other areas of the Gulf floor and pipeline burial in such stratas becomes very costly.

Continuous fathometer readings also were taken along the entire route to determine water depth and bottom profile. The bottom gradient was found to be very uniform and the maximum depth of water encountered was slightly under 100 ft.

Analysis of Survey Data and Design

It was necessary that information obtained from the soil analysis be correlated with wind and wave action that could be anticipated along the pipeline route. To assist in this work, Gulf Consultants of Houston, Texas, were engaged. The basis for determining varying burial depths and weighting of the line was a 25-year frequency hurricane, or theoretically the most severe hurricane that can be expected in any 25-year period.

Weight Coating

Core analysis revealed a gray silty clay over 85 percent of the pipeline route with a sandy clay or sand over the remainder of the route near the shoreline. The silty clay was found to have relatively low sheer strength, which presented a very critical design problem in weighting the pipe. The weight coating had to be sufficien ly heavy to prevent the pipe from floating out of the mud but not heavy enough to cause the pipe to sink into the mud in areas of low sheer strength, thereby developing spans in the pipe that would overstress it.

The fact that the pipeline is to be used for dual phase flow — that is, oil and gas flowing through the line simultaneously — further complicated the weight coating problem. The nature of dual phase flow is such that under certain conditions large slugs of oil and large slugs of gas flow intermittently. Therefore, a long section of pipe could either be full of gas or full of oil at a given time. Consequently, the weight coating problem became that of keeping the pipe from rising when full of gas and at the same time keeping it from sinking when full of oil.

The Authors

T. W. Sigler W. L. McNatt

T. W. Sigler is a graduate of Oklahoma State University with a BS degree in mechanical engineering. Since graduation he has been employed as a staff engineer with Continental Pipe Line Company. He has assisted in the design and construction of a number of pipeline projects and was directly connected with the Grand Isle offshore pipeline from the initial design through construction.

W. L. McNatt is a graduate of Oklahoma University with a BS degree in mechanical engineering. Since graduation he has been employed as a staff engineer with Continental Pipe Line Company. McNatt assisted in the design work on the Grand Isle offshore line and was project engineer in the construction of this project.

NORDBERG

MEMO TO: Management
After investigation and full consideration of all facts this committee recommends the installation of Nordberg engines for this pipeline project.

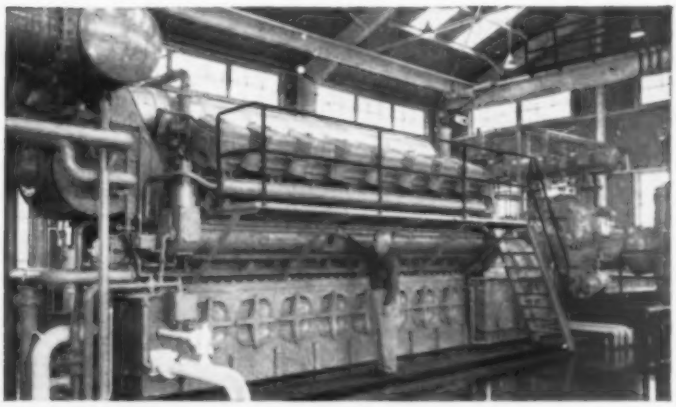
Chairman, Technical Committee

The Scene: Office of the Vice President in Charge of Operations, major gas transmission company.

The Problem: Selection of engine compressor units for gas pipeline expansion.

Recommendation: Install Nordberg *Supairthermal*® gas engine gear sets driving centrifugal gas compressors.

The Reason: Because the Nordberg units can be installed with lower capital investment, and operated at lower cost per horsepower-hour.



Nordberg Supairthermal **Engines are, by all standards, your best investment in modern prime movers for compact, economical, long term pipeline power. These powerful engines are built in both In-line and V-types, in sizes from 500 to 4,500 horsepower for Diesel, Duafuel® or Spark-Ignition Gas operation.**

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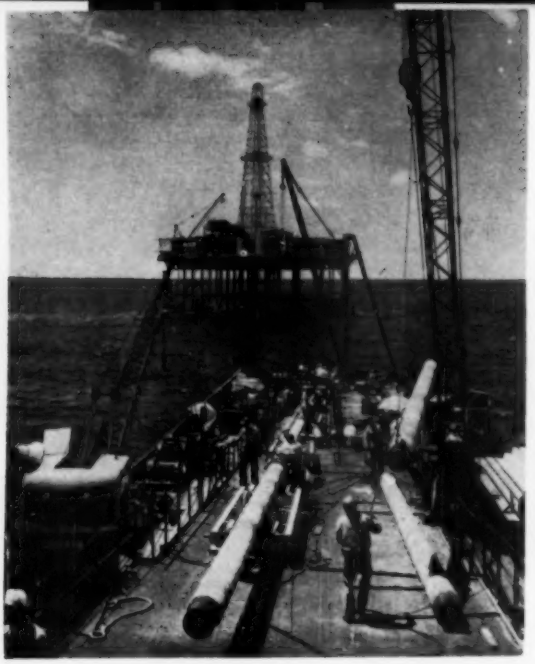

FIG. 3. Pipe was laid from barge by the "stove-pipe" method.

FIG. 4. Here the lay barge is operating in 90 ft of water.

An important characteristic of the silty clay is its tendency to plastic flow. Of course, this is most prevalent when sediment has been disturbed and has not regained any appreciable sheer strength. This situation exists in the unhealed ditch above a newly buried pipe. As the ditch above the buried pipe heals, it becomes more dense than the empty pipe while still retaining some of its viscous fluid character.

With this condition existing, any appreciable agitation could cause the pipe to float out of the ditch. Such agitation could be provided by mud waves, which are formed in the sediment by fluctuating pressure on the Gulf floor because of high waves. Agitation of these mud waves could cause a pipe to float out of the sediment and merely rest on the bottom.

As the above possibility is most critical while the ditch is unhealed, the problem was solved by filling the pipe with water as it was being laid, thereby keeping all pipe on the bottom full of water until the line was ready for use. Sea water, which was inhibited to prevent corrosion, was used for this purpose and presented no problem.

Pipe Burial

Pipeline burial depth was dictated primarily by hurricane scour action and mud wave action. Hurricane scour action is dependent on water depth and wave height and is most critical near the shoreline. Another factor to be considered is dragging anchors of vessels caught in a hurricane, which could possibly uproot and break a pipeline. Of course, the burial depth is a problem of comparing the cost of burial to various depths with the probability of the pipe being damaged at any given burial depth. In this case 10 ft burial was deemed necessary near the shoreline with 3-ft burial providing sufficient protection farther out in the Gulf.

Platform Riser Design

A problem that required serious consideration was the method in which the pipeline risers were to be brought up on the platform. Of utmost importance is the protection of such risers from vessels that might collide with them while attempting to dock.

The nature of the platform construction is such that it is probably impossible to bring the risers up inside the platform structure without using a flanged connection at the bottom. Any connection of this type, which would be susceptible to leaks, was felt to be undesirable. Therefore, the risers were brought up on the outside of the platform structure in the center of a platform end on which boats do not normally dock. This location affords some protection from damage by vessels, and, to assure protection, protective bumpers were built around the risers.

Space limitations on the platform and the attainment of good operations required that the risers on the central platform be grouped. Therefore, one bumper, constructed of 12-in. and 4-in. I-beams and extending a considerable distance above and below the water line, was designed to protect all present and anticipated future risers on the central platform. The bumper fastens to the main platform legs and is constructed to facilitate removal for the installation of future risers.

For the outlying platforms with only one riser, a different type of bumper was designed. The riser is encased with a larger diameter pipe from 10 ft be-

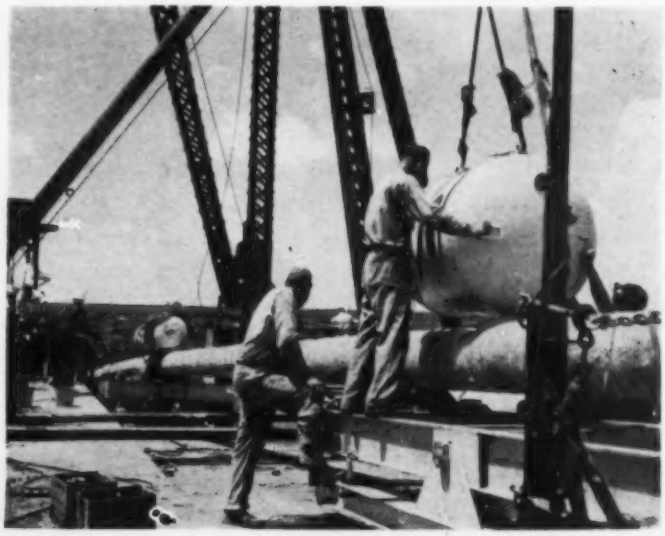

FIG. 5. Air tanks for buoyance control are being attached to pipeline.

low the water line to 15 ft above the water line. This casing is attached to a platform leg and structural cross members but not to the riser. The intention of this design is that any shock resulting from a boat colliding with the casing would be transmitted directly to the platform structure without seriously damaging the pipe.

Offshore Pipeline Crossings

The onshore everyday occurrence of one pipeline crossing another is not so simple offshore. If, in the event of such crossing, the bottom line should develop a leak, both lines would have to be raised to facilitate repairing the bottom one. This could prove to be very expensive, and if each line belonged to a separate company, the matter could become even more involved. For this reason the design of a gathering system warrants careful consideration.

Construction

Marine Gathering Company uses the "stove-pipe" construction method whereby the pipe is welded and laid joint by joint from a lay barge that moves along the right of way (Fig. 3). One of the first construction problems encountered was stress control on the pipe being lowered from the barge to the Gulf floor (Fig. 4). This problem became more pronounced as water depths up to 100 ft were encountered. To the knowledge of design engineers on this job no pipelines previously have been laid from a barge using the "stove-pipe" method in waters of this depth.

Futher complications of the stress control problem resulted from unusual conditions in certain areas along the pipeline route. Stress on the pipe being lowered from the lay barge to the bottom was controlled by adjusting the buoyancy of the pipe with air tanks, which were attached to the pipe on the barge and later released (Fig. 5). It was found that if an excessive length of pipe was suspended between the lay barge and the point of contact on the bottom, the severe shifting currents would swing and twist the pipe to the point of overstressing it and also make welding on the barge extremely difficult. As any size pipe can be weighed to any desired negative buoyancy, the higher structural strength of the 12-in. pipe made its stress control less difficult than the 8-in. or 6-in. pipe. Of course, stress control is more difficult during rough weather.

Adverse weather is a very prominent factor in the cost of laying offshore pipelines. It was found to be impractical to attempt to lay pipe in seas having swells much over 6 ft high. The only extensive shutdown periods experienced were during hurricanes Au-

Problem:

Scored or Worn Cylinders . . .

SOLUTION:

RESTORED TO DESIGN DIMENSION WITH PORUS - KROME • •

The 11 x 33 compressor cylinder shown above was received at the Van der Horst plant with the cylinder bore worn to 0.027" oversize PLUS scoring due to a frozen piston. The bore was cleaned up by machining at 0.056". PORUS-KROME and Vanderloy were electroplated to restore the bore to design 11".

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drey and Bertha, each of which interrupted operations for seven days. Squalls caused operations to cease for short periods of time but did not require the lay barge to leave location to seek shelter.

Another problem in undersea pipelining is the difficulty of keeping the pipe on the right-of-way. Before starting construction, one permanent buoy was set at the turning point in the main line, which is close to the midpoint, by electronic and visual survey methods. Initially, temporary buoys were set every two miles, but this was found to be useless because most of them were lost or moved by the time they were needed. Therefore, it became necessary to set temporary buoys for short distances periodically and to utilize a transit on the lay barge for checking purposes. The severe currents also made it necessary to check the position of the pipe on the bottom to insure that it was still within the right-of-way.

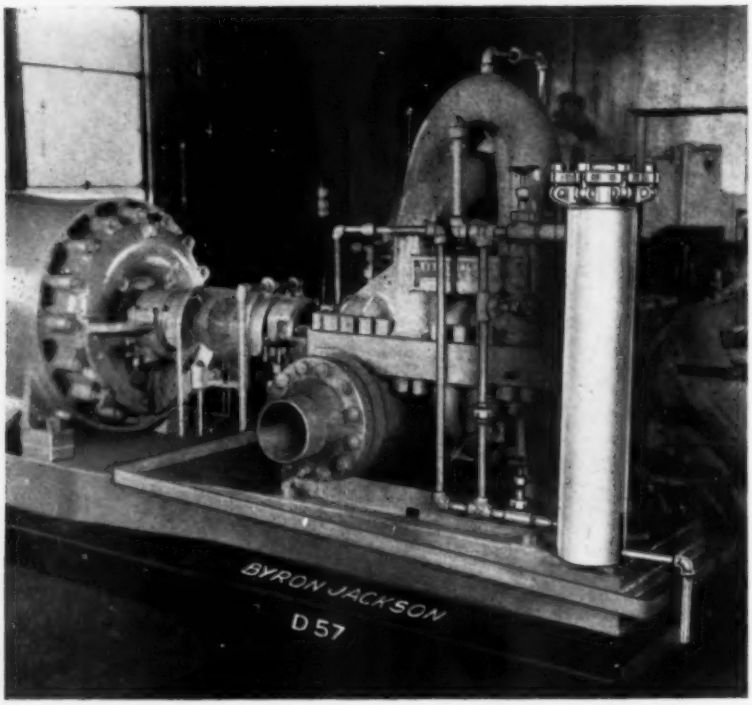
Underwater inspection of the pipe is necessary since nothing but the welding can be inspected above the surface. Elliot Marine Divers of Lake Charles, Louisiana, did the underwater inspection for the job. Their primary purpose was to inspect the pipe on the bottom for broken coating and kinked pipe and to inspect the burial depths after the pipe has been ditched. Radiographic inspection of 100 percent of the welds becomes economical with this sort of operation and was conducted on the lay barge. Therefore, the "picture" of each weld was inspected before it is moved off of the barge into the water. Pipe Line X-Ray Service of Houston, Texas, was awarded the radiographic inspection contract.

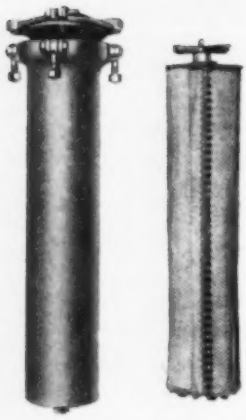
The only unusual problem that arose in the terminal construction was the exceptionally low soil bearing strengths. The terminal has 50,000 bbl of liquid storage capacity and excessive costs made piling supports for the tanks impractical. Therefore, foundations were constructed to allow tanks to settle 16 in. in the first three years until a point of stabilization is reached.

Daily progress in the offshore construction varied greatly dependent upon the problems arising and weather conditions. The record for pipe laid in one 24-hr period was 5800 ft, with the average being considerably less.

Although many problems are encountered in offshore pipelining that are new as well as interesting to "conventional onshore" pipeliners, the practicality of these lines for moving offshore production to market has been proved by this and other projects. It is anticipated that pipelines will continue to play a vital part in moving both gas and crude oil to market from offshore operations. ★ ★ ★

NUGENT FILTERS KEEP PUMP SEAL FLUID CLEAN AT PUSHBUTTON BOOSTER STATION





Nugent Fig. 1116HA-4L bag-type pressure filter of the type used to filter pump seal fluid at the Sterling City, Texas, booster station.

This Byron-Jackson centrifugal pump is in service at the Sterling City, Texas, booster station of American Oil Pipe Line Company, now owned by Service Pipe Line Company. At present, the pump is manually operated, but will be provided with microwave control from the mainline station at Colorado City, 40 miles north. At that time, Sterling will be unattended with the exception of an area supervisor at the site.

A Nugent filter on the Byron-Jackson unit protects the pump seal fluid, keeping it free of foreign matter which could cause seal leakage and eventual shutdown and lockout of the pump.

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M. J. Paul
Chief Engineer
Natural Gas Pipeline Company of America

UPDATING a Pipeline System

Placed in operation in 1930, Natural Gas Pipeline Company of America's system has been progressively modernized to keep pace with advancing technology

MODERNIZATION is usually defined as an updating technique that changes the character or application of a particular process to keep pace with advancing technology. The advances in pipeline technology have been rapid and far reaching in effect. Adaptation of new developments to our existing plants is an excellent example to modernization. With the several modernization programs we have undertaken, we have been able to improve operating efficiency, better operating conditions, promote safety, and increase fuel economy.

Natural Gas Pipeline Company of America in 1929 and 1930 constructed the first long distance large diameter high-pressure natural gas transmission pipeline from the Panhandle field of Texas to the terminus at Joliet, Illinois, a distance of 847 miles. To maintain flow efficiency, one field station and nine compressor stations were constructed. One additional field station and one main line station were added later on as flow rates were increased. These stations are all self-sufficient, having their own electricity, fuel, and water facilities, a separate communications system between stations, and living quarters for all key operating personnel. They were constructed to incorporate the latest engineering thinking of that day and operated as efficiently as could be expected from the kind of equipment then in service.

The major modernization programs of the Natural Gas Pipeline Company consist of the following:

1. **Remotely controlled blowdown systems.**
2. **Modified closed cooling-water systems.**
3. **Supercharging compressor engines.**
4. **Exhaust tuning of auxiliary engines.**
5. **Exposure of manifold piping.**

Paper presented before ASME Petroleum Mechanical Engineering Conference, Tulsa, Oklahoma, September 22-25, 1957, under the title "Modernization."

Remotely Controlled Blowdown System

A measure of the success of our work is reflected in the safety that we provide for our operators as well as protection for equipment. A significant advancement of these precautions at our compressor stations has been the installation of a remotely controlled blowdown system.

As originally conceived, the design of Natural's compressor stations called for remotely controlled suction and discharge block valves at each station to isolate it from the pipeline in the event of piping or equipment failure and to permit revision of station piping. It became obvious that in the event of fire the gas that would be trapped in the station could cause considerable damage by burning. A method of releasing this gas at a location of least hazard was desirable. It was decided that the blowdown system should vent all the high-pressure gas in one minute or less at a selected remote point. These valves are operated pneumatically by a piston connected to rack-and-segment gears on the valve stem. Control stands at strategic locations in the plant area control the flow of gas under pressure from a permanent reservoir to the pistons, which quickly close the suction and discharge block valves and cause the blowdown valves to open within 10 sec even though they may be 1000 ft away.

In the design of the Texas-Illinois system, a recently constructed affiliate, a remotely controlled blowdown ar-

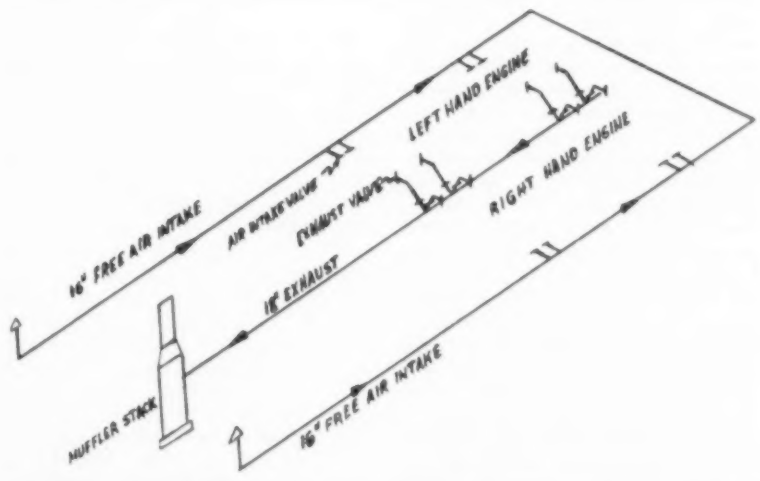

FIG. 1. Diagram of original engines installed on system.

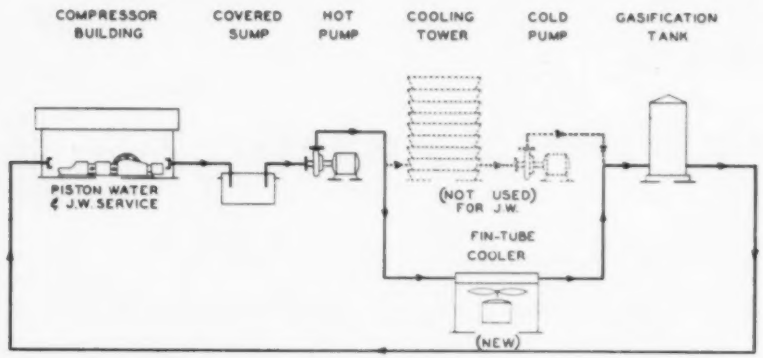

FIG. 2. Modified engine water-cooling system.

rangement was installed in conjunction with the shutdown system. Operation of this system proved very satisfactory and a similar arrangement has been designed by Natural Gas Pipeline for its main line stations. All valves used in the blowdown system are opened by piston action and can only be closed manually. Automatic compressor engine ignition shutoff also is a part of the system. Fuel gas to the compressor engines is carried at 30 psi. It must be shutoff immediately to prevent detonation in the engines or exhaust system. A fuel gas shutoff device has been incorporated with the ignition shutdown to handle this situation. Although the high-pressure gas is vented, it is still necessary to have power available from our gas-driven generating units. An emergency source of fuel gas for the auxiliary engines is provided by a pipeline tap on the line side of the station block valves. This tap, while assuring a permanent gas supply, also serves as the discharge pressure gage connection. A pneumatic valve operator causes a valve in the fuel gas meter run to open at the same time as the blowdowns are opened in order to maintain fuel gas pressure to the auxiliary engines, which, in turn, operate our fire protection system.

At our two field stations where compression, dehydration, and gasoline stripping facilities operate side by side, the shutdown requirements are somewhat different in that a too rapid blowdown in our gasoline plants would cause fluid loss from the stripping units and tray upset at the dehydration towers. As before, the entire station is isolated by block valves with the gasoline and dehydration plant being isolated separately. A separate control valve stand in the gasoline plant area can be manipulated to open the gasoline plant blowdown valves with automatic valve operators. Also, at our field stations the emergency fuel gas to the auxiliary engines is controlled by automatic valve operators.

Although we have not had to call upon the new systems for emergency purposes, they have performed well when tested, and 1957 will see this system of blowdowns installed at all locations.

Modified Closed Cooling-Water System

Water utilization in the states where our pipeline operates is assuming a critical nature. Once plentiful, water sources are dwindling rapidly. As a result we have had to revise our entire system of water cooling.

The original cooling facilities installed at the main line compressor stations were atmospheric towers. These towers cooled the discharge gas as well as the engine piston and jacket cooling water. Experience taught us that the atmospheric towers were subject to algae growth, which seriously reduced their efficiency. It was possible to remedy this situation although it required a great deal of maintenance expense. As developments in industrial cooling progressed, the induced-draft cooling tower was considered and then adopted to replace the atmospheric towers. Efficiency was improved and algae growth eliminated.

In the 1930's and 1940's water for cooling was available in the amounts needed at all locations although the typical station daily consumption was 150,000 gal. The continuous use of this much water required the drilling of additional wells from time to time as older wells became exhausted or lost capacity due to falling water tables. By 1955 this situation had become acute at the stations in Iowa to the point where in summer our daily requirements were barely met by the system of water wells we had drilled.

An investigation of the recently developed closed water systems revealed

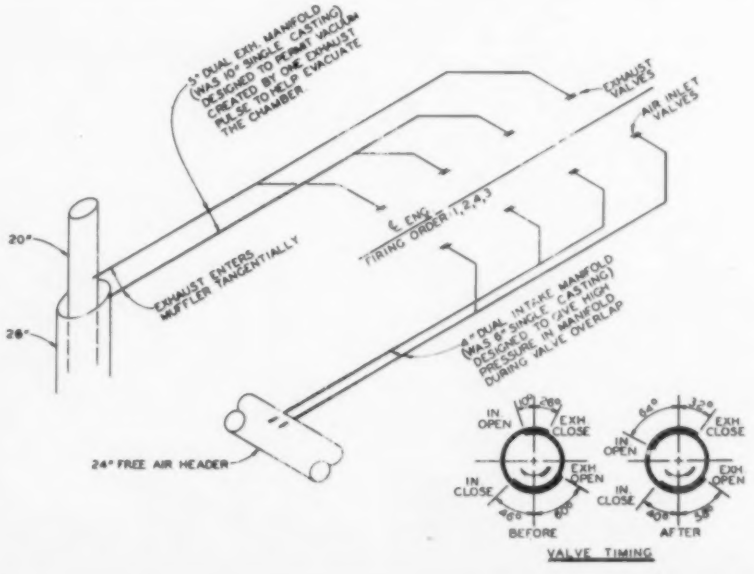
5" DUAL EXH. MANIFOLD (WAS 10" SINGLE CASTING) DESIGNED TO PERMIT VACUUM CREATED BY ONE EXHAUST PULSE TO HELP EVACUATE THE CHAMBER
EXHAUST VALVES
AIR INLET VALVES
6 ENG. FIRING ORDER 1, 2, 4, 3
20°
28°
EXHAUST ENTERS MUFFLER TANGENTIALLY
4" DUAL INTAKE MANIFOLD (WAS 6" SINGLE CASTING) DESIGNED TO GIVE HIGH PRESSURE IN MANIFOLD DURING VALVE OVERLAP
24" FREE AIR HEADER
IN OPEN
EXH CLOSE
IN CLOSE
EXH OPEN
BEFORE
AFTER
VALVE TIMING

FIG. 3. Supercharging by tuning.

several conditions that were particularly desirable. It was determined that we could reduce our consumption from 150,000 gal per day to a maximum of 7000 gal per day. Inasmuch as the entire quantity of water required lime treating, our treating expense could be reduced greatly. Also, the sludge disposal problem connected with lime treating was greatly modified. The tremendous reduction in throughput would make zeolite treatment feasible, which would eliminate the sludge problem entirely. Corrosion could be mitigated greatly by a closed water system. The open systems as installed were the source of a great deal of corrosion owing to the oxygen dissolved into the water during the cooling process. To eliminate the oxygen, we had constructed elevated gasification tanks where main engine fuel gas was bubbled into the water passing through the tanks to absorb oxygen.

In developing the closed system, it was decided to use air-cooled finned-tube heat exchangers where great quantities of air are forced across the tubes. Special structures had to be purchased for this purpose. Existing pumps were incorporated into the revised system and the piping utilized where possible. The gasification tower now serves as a surge tank. The water from the pumps is delivered to the coolers through a by-pass arrangement that maintains the desired temperature, thence to the gasification tower, which maintains the constant head on the water entering the engine jackets and pistons.

We are able to maintain water at a 150 F inlet and 170 F outlet temperature range at the engines under all atmospheric conditions and operating variations. Experimentation with this arrangement has indicated that an additional pump was required to increase slightly the water pressure to the pistons. Again, all modifications were accomplished with few changes and no additional major equipment items except, of course, the new coolers. These modifications have considerably improved our operating economy and efficiency.

Supercharging Compressor Engines

In 1929 Natural Gas Pipeline Company constructed nine main line compressor stations each having five 1250-ichp* horizontal engines. As market demands increased, additional engines were installed at various locations to provide additional capacity. These installations were made at considerable expense.

In 1951 it was determined that the horizontal engines were adaptable for supercharging. The first installation was made at our station at Hooker, Oklahoma, and it was found that we were able to increase horsepower by 40 percent to 1750 ichp. Inasmuch as supercharging was not feasible at the time the engine had been designed, the arrangement whereby that could be accomplished was somewhat complicated. It was necessary to remove the entire existing exhaust line and muffler and replace it with individual 6-in. exhaust lines from each power piston, which are directly connected to the exhaust turbine. Exhaust gases go from the turbine to the reused muffler situated nearby. The pulse-type turbine on the exhaust is coupled to the air intake turbine to increase air pressure to a maximum of 5 psig. Fuel gas to the power cylinder has been increased to 25 psig.

Although this pressure may seem high, the small amount of gas injected into each cylinder does not upset the air flowing into the pistons at the lower pressure. New cams are used to increase and intake and exhaust-valve overlap. Scavenging thus created improves combustion.

Fuel gas requirements for supercharged engines is on the order of 7.5 cu ft of 1023-Btu gas per hp-hr. Maximum fuel economy for regular units is about 9.5 cu ft per hp-hr. It soon developed that ambient air conditions altered combustion conditions in the cylinders because of variations in air density. It was necessary to install a pressure regulator operated by ambient air temperatures to keep the fuel and air mixtures constant.

Supercharging has not caused the exhaust temperatures to increase, as the improved scavenging functions to keep the jacket-water cooling load approximately the same as it had been. New safety devices were required for the new equipment. Increased fuel pressure made it necessary to install automatic shutoff valves on the fuel lines to the engines, which will close on ignition failure. In addition a turbine oil failure alarm is necessary to make the operator aware of impending shutdowns due to turbine trouble.

This type of equipment has been operating at our Hooker station for three years. In 1956 one unit at each of two of our other main line stations was supercharged with good results. We are currently engaged in a program of supercharging main line engines that will greatly increase our available system horsepower. No significant piping revisions due to the increased capacity are required as the original design of the manifold piping had been quite conservative. Compressor buildings will have to be widened to accommodate the new equipment.

The resulting increase in system horsepower was achieved at a fraction of the cost that would be required for installing new compressor engines and their related equipment.

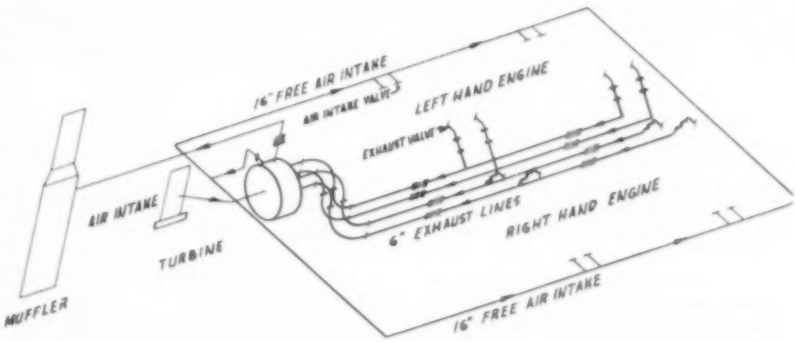

FIG. 4. Diagram of supercharged engine.

Exhaust Tuning of Auxiliary Engines

Each of the main line stations is equipped with two 175-kw and one 188-kw generating units. The two 175-kw units are driven by 4-cylinder, 4-cycle, 260-brake hp prime movers. The supply provided by this equipment proved ample for the first years of operation. As time went on, however, more and more electrically operated

*Internal combustion hp.

equipment was being utilized at the stations. In addition, the increased use of electrical appliances in the cottage areas stepped up the kilowatt loading. Several years ago as the power situation became acute the several means of increasing available electricity were investigated.

Any increase in generating facilities was not feasible in the existing building. The most promising prospect was a method by which we would increase the horsepower rating of the existing prime mover without having to alter the generator. Fortunately the generators originally purchased had been sized conservatively and could produce additional kilowatts of electricity up to 275 kw if the prime mover could be adapted to put out the extra horsepower. The cost of such an increased output, of course, was far less than the cost of entirely new facilities.

The initial conception called for an electrically driven blower to deliver air at 1½ to 2 psi to an evaporative type cooler without altering valve timing or using fuel gas injection. Experimentation with the blower revealed that a different exhaust valve timing was necessary, that is, exhaust pressure pulses from the cylinders would have to be altered to achieve satisfactory operation. Several variations of sizes and lengths of exhaust piping were tried before a satisfactory design was achieved. This design required 5-in. exhaust piping of suitable length to accomplish the harmonic effect called "tuned exhaust." Fuel gas injection and individual air-control valves were utilized to improve performance. By this time it was decided to eliminate the electric blower inasmuch as the increase in horsepower was offset by the power needed to operate the blower. Thus, we rely on exhaust tuning alone to increase the horsepower output of the engine. As the units run at a constant speed, exhaust tuning is feasible.

In addition it was necessary to alter valve timing to amplify the effects of tuning. Units are now capable of operating at the rated load of the generator, namely 275 kw, an increase of more than 50 percent of usable capacity at a very low increase in cost. Updating the generators has allowed the company to continue other improvement programs without the installation of costly additions to generating equipment and structures.

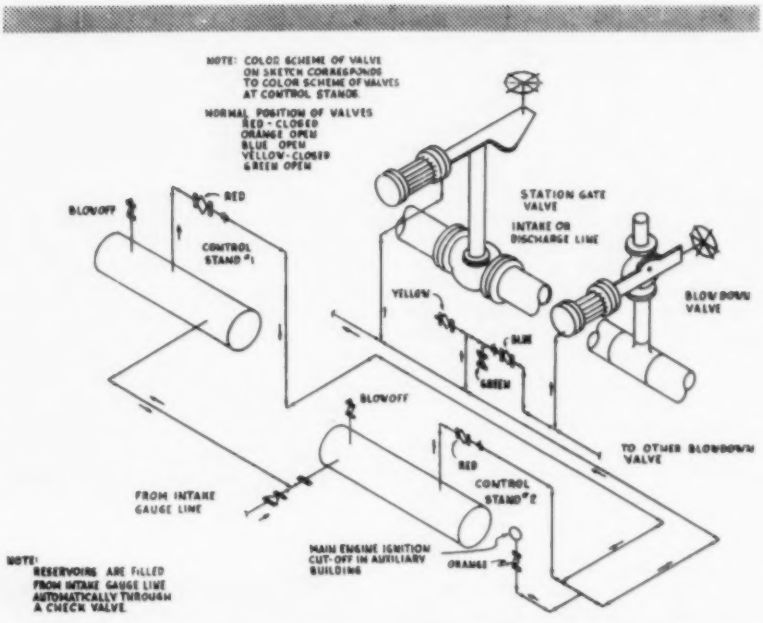

FIG. 5. Diagrammatic sketch of remote control for main intake and discharge valves, and station blow-down valves.

Exposure of Manifold Piping

At the time of our original construction in 1929, it was considered good practice to install piping headers underground. The main line stations were constructed in this fashion with the suction and discharge header installed below grade parallel to the compressor building. Individual 6-in. leads were installed to and from each compressor, a total of four lines per engine. The first modification was in the first years of operation when the starting by-pass lines, and relief valves, were relocated to the manifold area outside the compressor building.

As part of normal operating procedures the underground piping at the compressor stations was inspected periodically to keep a close check on the condition of the piping. Any indication of advanced corrosion called for immediate replacement of the corroded section. Every five years all underground piping in the manifold area was cleaned to bare metal and recoated.

In 1949, at the time one of our field stations was being expanded, the manifold piping design was altered to the extent that the new discharge lines from the engines to the cooling towers were all installed above grade. Piping from the cooling tower went below grade, as it had been previously. In addition, the long header sections were revised to reduce and control vibration and pulsation. In spite of stringent maintenance, however, the piping that had been in service for 20 years had deteriorated to the point of almost complete replacement. In connection with this replacement, it also was decided to build "sunken gardens," which would expose all manifold piping in stalled on original construction and thus facilitate easier inspection, simplify repair and maintenance, and eliminate electrolytic corrosion.

Another modification made at this time was to eliminate the vertical sickle bends that were installed on the discharge lines at the cooling tower. The Z-bends now installed are easier to hold down and consequently are not subject to vibration stresses, which are a primary cause of piping fatigue failures.

Suction and discharge piping design for piping installed under our expansion programs, was altered so that one 8-in. suction and one 8-in. discharge line were installed per engine. All main line compressor stations have been equipped in this fashion. The ease of maintenance has been well received by our operating personnel. Simplifications of the newer piping has helped improve operating conditions.

The effort of the several modernization programs has been to keep our installations current. We have been able to take advantage of technological advances to improve efficiency and operating economy. Naturally, other modifications of a minor nature are occurring constantly.

Each of the changes described here represents a major alteration to the compressor station properties. These alterations came into being only after detailed investigation and consideration during the planning stages. Future modifications to keep us in step with modern pipelining will be handled in like manner. ★ ★ ★

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Compressor and engine jacket systems require

Proper Water Conditioning

Otto H. Preis
Engineering Department
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THROUGHOUT the years the problems connected with the removal of heat from engines and compressors have received considerable attention from manufacturers, users, and water treatment consultants.

Early engines and compressors were designed for use with low temperature water at low viscosity. These designs resulted in a large temperature rise through the system, which set up unequal stresses in the metal, causing frequent failures. To overcome this problem and to increase the efficiency of the equipment, manufacturers' designs have been changed so that modern engines now operate with a rapid flow of water at a relatively high temperature with a temperature rise of only 10 to 15 F throughout the system.

The problems with cooling systems that still confront the operator and scale formation and corrosion in closed recirculating systems and the additional problem of bacteriological fouling in open systems. Each of these three factors can cause loss of heat transfer, reduced water flow, hot spots, and plugged water passages with resultant loss of efficiency or equipment failure. These conditions can be prevented with proper water treatment. Three types of cooling water systems should be considered: (1) Once-through systems, (2) closed recirculating systems, and (3) open recirculating systems.

Once-Through Cooling Systems

As the name implies this type of system uses water on a once-through basis from some plentiful, cheap source such as a river or lake. This type of system was usually employed in older equipment operating with low temperature water at low velocities. Once-through cooling systems usually cannot be used with present day equipment because of the low, sometimes variable, temperature of such a supply. Even if proper temperatures could be obtained by heat exchange in other portions of the plant, the cost to treat such a large quantity of water for complete scale and corrosion prevention would be prohibitive.

Scale is formed by the precipitation of calcium and magnesium salts present in the water. At the elevated temperatures found in engine jackets, the bicarbonate alkalinity of the water will break down to form carbonate alkalinity. As calcium carbonate has an inverse solubility curve, e.g., is more insoluble at higher temperatures, this precipitation will occur on the metal surfaces at the hottest portions of the system.

Fig. 1 shows the analyses of typical scales from once-through cooling water systems. Scale formation can be minimized by the use of surface active agents such as polyphosphates and certain organic materials. Because of the high temperatures involved, scale formation with hard waters cannot be completely eliminated. The constant supply of scale-forming salts in a once-through system will result in a gradual build-up of scale that eventually will cause failure of the equipment.

Corrosion and pitting are caused primarily by dissolved oxygen present in the water supply. Other acidic gases such as carbon dioxide and hydrogen sulfide also contribute to corrosion. In a once-through cooling system the constant flow of fresh water provides a continuous source of these corrosive agents to the system. Corrosion prevention under such conditions can be obtained only at a very high cost.

If oxygen is the chief cause of corrosion it can be removed from the water by vacuum deaeration or by the feed of a catalyzed sodium sulfite, which will react completely and quickly with the dissolved oxygen at low temperatures.

Surface active phosphates will provide a small degree of corrosion protection (see Fig. 3) and will aid in keeping the system free from the build-up of corrosion deposits. Certain patented treatments have been developed recently, such as the Dianodic[1] system of treatment, which can provide very good corrosion protection under these conditions. It is not generally economical, however, to provide suitable scale and corrosion preventive treatment to a once-through engine jacket system for *complete* protection. Such a system would be treated at a level just high enough to permit trouble-free operation between frequent scheduled shutdowns at which time the system would be acid cleaned. This type of operation results in reduced efficiencies and shortened equipment life. Thus, the *closed recirculating system* is the one most commonly used today in engine and compressor service.

Closed Recirculating Systems

A closed recirculating system is one in which the same water is continuously circulated through the engine and compressor jackets where it picks up heat. The heat is discharged from closed coils in a cooling tower (open recirculating system), or to the air in a radiator type cooler. A surge tank usually floats on the line to provide for expansion of the water and to insure an ample supply of water for the jackets at all times.

[1]Kahler, H. L., U. S. Patent No. 2,711,391.

FIG. 1. Analyses of Typical Scales from Once-Through Cooling Water Systems.

	%	%	%	%
Calcium as CaO	47.2	34.4	43.5	52.3
Magnesium as MgO	2.1	1.7	0.6	4.1
Iron and aluminum as R_2O_3	4.6	26.9	11.6	3.2
Sulfate as SO_3	0.9	0.1	1.4	0.3
Silica as SiO_2	4.9	9.8	2.1	1.1
Carbonate as CO_3	34.2	22.9	34.0	35.2
Organic and Oil	5.9	4.1	6.4	2.1

Presented before American Gas Association Engineering Conference, Philadelphia, Pennsylvania.

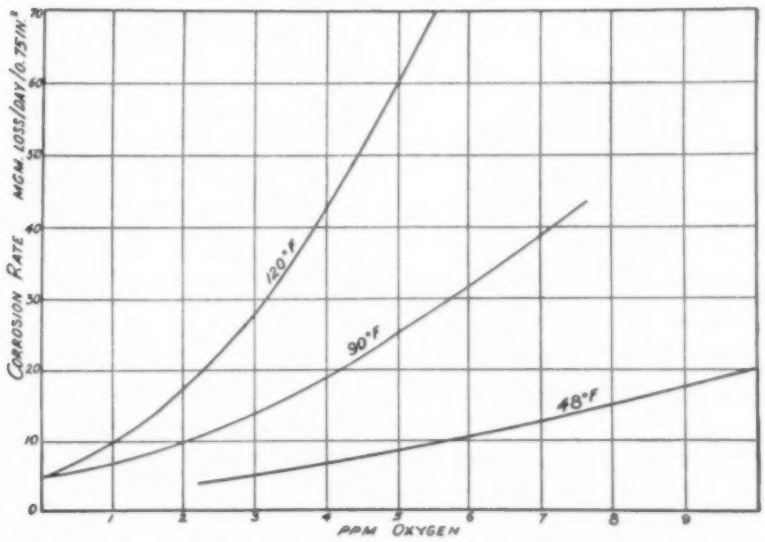

FIG. 2. Effect of oxygen concentration on corrosion at different temperatures.

The only losses from this closed system will occur at the pump packing or through leaking joints. Thus, the makeup requirements are very small. This type of system is ideally suited to modern engine and compressor jacket operation because a large quantity of water at carefully controlled temperatures can be circulated through the equipment.

Because of the very low makeup requirements it is possible to completely eliminate scale and corrosion at a nominal treatment cost. If boiler facilities are available on the plant site, the system should be filled with condensate, and condensate should be used for makeup when needed. As no mineral salts are present in pure condensate, no scale formation can occur. If condensate is not available, then zeolite softened water should be used. A small household type zeolite unit will usually be adequate because of the small amount of makeup water required. Zeolite softening will remove practically all calcium and magnesium salts from the water. The total hardness of the effluent of a zeolite softener will be in the range of 0 to 2 ppm so that scale formation will be negligible.

If unsoftened water must be used in the closed system then some scale formation will occur. The usual surface active agents, such as polyphosphates, employed to sequester scale forming salts will break down in this service because of the long, almost unlimited retention time and high skin temperatures encountered.

Other sequestering agents that might not break down under such conditions would attack pump packing causing excessive maintenance and water loss.

Although there is no successful method to completely eliminate scale formation with hard water, some systems do operate with such waters with little apparent difficulty. Once the hardness present in the water has precipitated, the system will contain soft water. With water losses kept at a minimum, little additional hardness will be introduced to the system.

Depending on the amount of hardness originally present, the water velocity, mechanical nature of the water passages, and temperatures encountered, the scale deposited in the system may not be sufficient at any one place to cause any more difficulty than an insignificant loss of efficiency. Of course, the continued addition of hard water eventually will necessitate acid cleaning of the unit.

The only way to insure scale-free surfaces in a closed engine jacket system is to use water containing no scale forming salts!

With scale formation eliminated, the only other problem encountered in closed systems is corrosion. As most systems have a surge tank floating on line, the circulating water is constantly exposed to air, from which it picks up by diffusion small quantities of the corrosive gases oxygen and carbon dioxide. With this continuous supply of corrosive gases, and the relatively high temperatures, corrosion can proceed at a rapid rate.

Fig. 4 illustrates data on the increased corrosion caused by oxygen at higher temperatures for two different conditions. Curve A represents results obtained in a system where venting of oxygen to the atmosphere was not permitted. Increase in corrosion rate with temperature was practically a straight line. Curve B shows data in a system where venting of oxygen to the atmosphere was permitted. As can be observed, both curves are parallel and quite close together until approximately 170 F. Curve B then drops off because the lower solubility of oxygen at this temperature is a freely vented system is decreasing the corrosion rate faster than it is increased by temperature. Although the temperature of the circulating water is approximately 160 F, the skin temperature of the jacket walls will be considerably higher. The oxygen released at these points of high heat transfer will cause severe corrosion.

The most efficient method of preventing corrosion is the use of high concentrations of chromate base corrosion inhibitors. Concentrations in the range of 1000 to 2000 ppm of such inhibitors will stifle successfully this corrosive attack. The pH of the circulating water must be maintained within reasonable limits so that no free mineral acid nor extremely high alkalinity concentrations are present. A pH range of 6 to 8 can be easily maintained in the system.

In certain plants where it is necessary to drain the jacket water on occa-

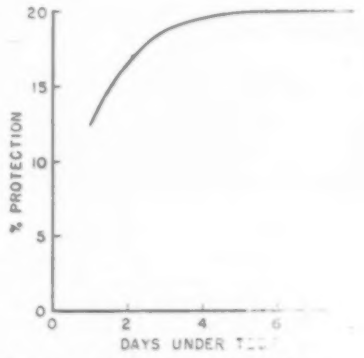

FIG. 3. Inhibition of corrosion with 2 ppm polyphosphate.

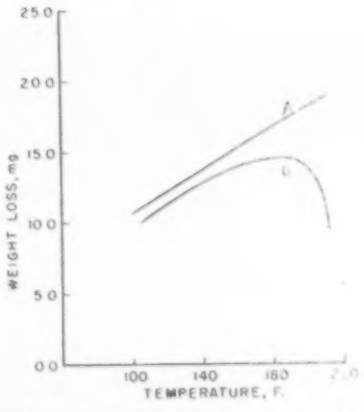

FIG. 4. Effect of temperature on corrosion rate — unvented vs vented.

(1) $2Na_2CrO_4 + 3H_2S + 5H_2SO_4 \rightarrow$
sodium chromate + hydrogen sulfide + sulfuric acid →

$Cr_2(SO_4)_3 + 3S + 2Na_2SO_4 + 3H_2O$
chromic sulfate + sulfur + sodium sulfate + water

(2) $Cr_2(SO)_3 + 6NaOH \rightarrow 2Cr(OH)_3 + 3Na_2SO_4$
chromic sulfate + sodium hydroxide → chromic hydroxide + sodium sulfate

sion there may be objections to high chromate concentrations from a disposal standpoint. Many states have laws governing the amount of hexavalent chromium that can be discharged into rivers or streams because of toxicity. These objections can be overcome by reducing the hexavalent chromium to the trivalent chromic salt with copperas ($FeSO_4 \cdot 7H_2O$) or sodium sulfite and precipitating it with lime or caustic soda as chromic hydroxide. The reactions involved are shown in Fig. 5.

Where sour gas leakage into a chromate treated system is experienced, the hydrogen sulfide in the gas will reduce the chromate to the insoluble chromic oxide.

This reaction not only destroys the corrosion inhibitory properties of the system, but results in the formation of a sludge, which will deposit in the system. The best solution to this problem is to eliminate such leaks by tightening up the system and replacing gaskets where necessary. Gas leaks can be detected at the surge tank by smell or by a gas detector.

Another means of checking on gas leaks is to have a sight glass installed on a water line from the jackets. The cooling water will have a cloudy or aerated look if gas leakage is occurring. Increased treatment consumption, over that required by the makeup water, will also give an indication of gas leakage.

If, for some reason, such gas leaks cannot be eliminated then chromates cannot be used. It is necessary then to resort to some other type of treatment, such as sodium nitrite in concentrations of 2000 to 3000 ppm. Such a treatment will provide reasonable corrosion protection for ferrous metals, but nitrites are not very effective corrosion inhibitors for copper alloys in the presence of hydrogen sulfide. It is also difficult to test and control a nitrite base treatment. It is more satisfactory to review maintenance procedures and

FIG. 5. Chemical Reactions Involved in Chromate Removal Systems.

I. Chromate reduction with ferrous sulfate:

(1) $2Na_2CrO_4 + 6FeSO_4 + 8H_2SO_4 \rightarrow$
sodium chromate + ferrous sulfate + sulfuric acid →

$Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 2Na_2SO_4 + 8H_2O$
chromic sulfate + ferric sulfate + sodium sulfate + water

(2) $Cr_2(SO_4)_3 + 6NaOH \rightarrow 2Cr(OH)_3 + 3Na_2SO_4$
chromic sulfate + sodium hydroxide → chromic hydroxide + sodium sulfate

II. Chromate reduction with sodium sulfite:

(1) $2Na_2CrO_4 + 3Na_2SO_3 + 5H_2SO_4 \rightarrow$
sodium chromate + sodium sulfite + sulfuric acid →

$Cr_2(SO_4)_3 + 5Na_2SO_4 + 5H_2O$
chromic sulfate + sodium sulfate + water

(2) $Cr_2(SO_4)_3 + 6NaOH \rightarrow 2Cr(OH)_3 + 3Na_2SO_4$
chromic sulfate + sodium hydroxide → chromic hydroxide + sodium sulfate

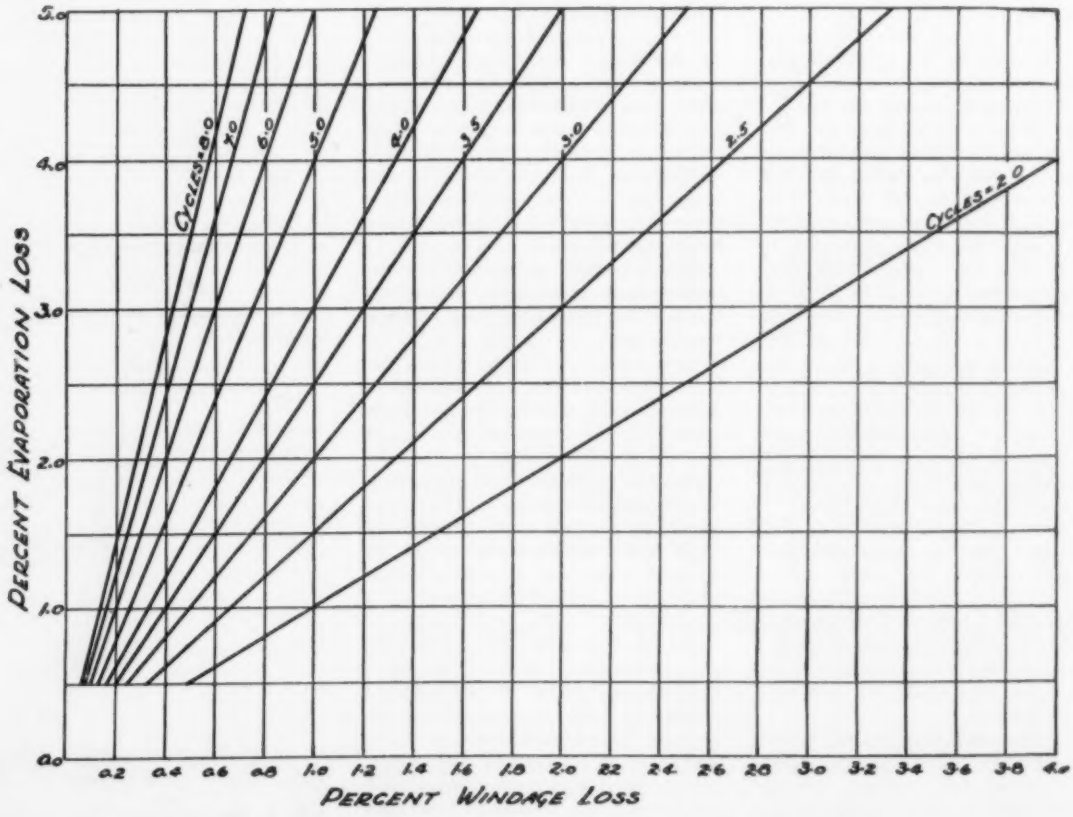

FIG 6. Relationship between evaporation loss, windage loss, and cycles of concentration.

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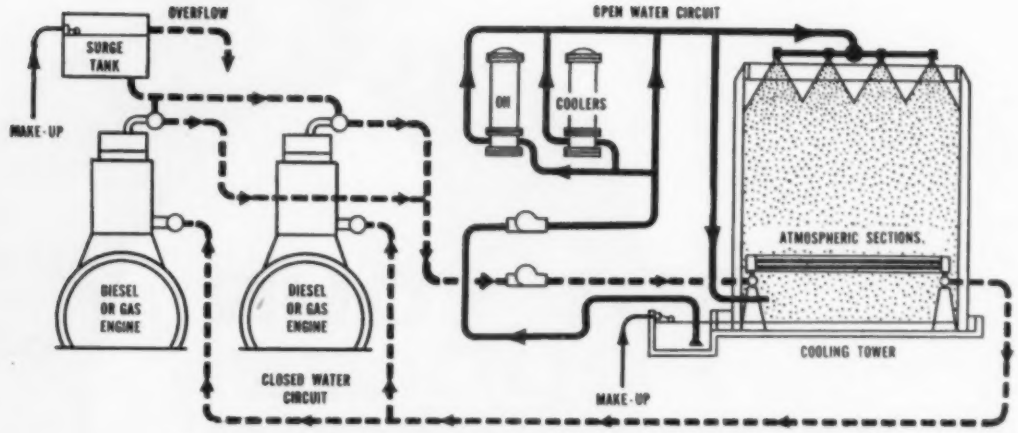


FIG. 7. Typical flow diagram of cooling tower system in diesel and gas engine service.

eliminate gas leakage so that the more effective chromate treatment can be used.

Open Recirculating Systems

In an open recirculating system, the water is cooled by the evaporation of a part of the water in a cooling tower or spray pond. A complete discussion of the operation and treatment of open recirculating systems could extend the length of this paper indefinitely. Such systems are not usually employed for direct engine or compressor jacket cooling, but they provide the most common means for removing heat from the closed system. Therefore, a discussion of small cooling tower systems and their treatment is necessary.

In an open system approximately 1 percent of the water passing over the tower is evaporated for each 10 degree drop in temperature. This evaporation results in the concentration of the salts present in the water. There is also a "windage" loss (drift of circulating water) from the tower, which, when supplemented by blowdown of the circulating water, will restrict the cycles of concentration (or build-up of salts) to a predetermined level. The relationship between evaporation loss, windage loss, and cycles of concentration is shown in Fig. 6.

In passing over the tower the water is constantly saturated with oxygen from the air in addition to picking up carbon dioxide and any other corrosive gases in the atmosphere. The water also picks up airborne organisms, which can result in a slime and algae problem.

Although makeup water requirements for a particular heat transfer problem are considerably less for a tower system than for a once-through system, they are considerably more than for a closed system, which has negligible losses. Therefore, it is not usually economical to completely remove the scale-forming salts from the makeup water to an open system. Nor is it necessary in most cases, as the retention time in open systems ranges from several hours to several days, and sequestering agents can be successfully employed for this period of time. Any fluctuations in control, however, can result in scale formation.

Corrosion can be successfully controlled by numerous methods of treatment, which can be designed to handle practically any type of corrosive environment. Here again critical controls are sometimes necessary. Slime and algae growth can be controlled by chlorination and/or the use of commercially formulated materials.

Although scale formation, corrosion, and organic fouling can be minimized successfully in open systems, the necessity for consistently good heat transfer for long periods of continuous service in engine and compressor jackets favors the more easily treated closed system for direct jacket cooling. Open system are ideally suited, however, to cooling the water in the closed system.

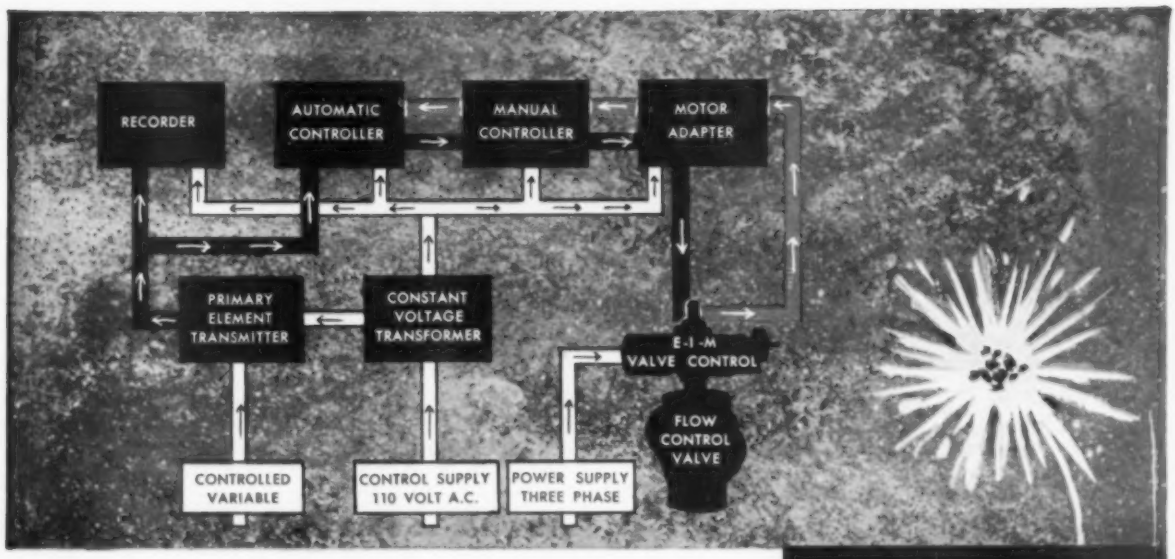
Fig. 7 shows a typical flow diagram for such an installation. This cooling is accomplished either by placing the coils of the closed system directly in the tower or with suitable heat exchange equipment external to the tower. With such an arrangement, the flow of tower water is relatively unobstructed so that minor fluctuations in control will not hinder effective heat transfer. Also, the skin temperatures of the heat exchange equipment would be only as high as the water temperature of the closed system, approximately 160 F, whereas skin temperatures in the jackets themselves would be several times as high. The skin temperature of the heat transfer surface has considerable bearing on the scaling function because of the inverse solubility curve of the scale-forming salts as explained earlier.

Although the treatment of open recirculating systems can be quite complex depending on the size of the system, nature of the makeup water, and heat exchange characteristics of the system, a small cooling tower system used in conjunction with a closed system normally can be easily treated. For scale prevention it is necessary to prevent the breakdown of the natural bicarbonate alkalinity of the raw water to the carbonate form. Depending on raw water characteristics this breakdown can be prevented by properly restricting cycles of concentration or by the feed of acid. In addition, the chemical treatment should contain surface active agents to increase the solubility of the scale-forming salts. The surface active agent will provide added protection in the event of normal fluctuations in control. Effective corrosion control usually can be obtained with 100 to 200 ppm of a chromate base inhibitor.

A discussion of the many systems of treatment available to combat each individual problem would require as many different papers as there are problems. Each cooling system should be carefully evaluated by a water treatment engineer so that the proper type of treatment can be applied.

Although open recirculating systems provide the primary means of cooling the closed jacket circulating water, air cooling of jacket water has also received considerable attention. Although air cooling does not have the flexibility of open recirculating systems, it can be successfully employed in certain areas of the country at costs comparative to that of the open system.

With the recent advancements made by water treatment engineers in the development of corrective methods and chemicals for cooling water systems, almost any cooling water problem can be controlled adequately so that trouble-free operation will be insured.★ ★



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General view showing physical testing area of Caterpillar's new Production Metallurgical and Materials Testing Laboratory.

NEW LAB TESTS — CATERPILLAR MATERIALS

THE NEW Production Metallurgical and Materials Testing Laboratory at Caterpillar's Peoria, Illinois, plant is one of the world's most modern facilities of its type. Its function is to insure that all materials used in the manufacture of Caterpillar machines are rigidly controlled throughout all stages of manufacture, and to develop new metallurgical practices and methods of evaluation.

Personnel of the laboratory have many responsibilities. All new products from suppliers are evaluated. New methods of testing are developed to achieve the highest possible accuracy. Control of all materials must be maintained during processing. Proper process procedures are designated for standardizing operations. Tooling and other equipment is prescribed to meet metallurgical requirements, and new applications are developed. Data are provided to personnel concerned with improvement of product or manufacturing techniques. Laboratory personnel assist in the making of purchasing decisions and in the inspection of materials.

The laboratory tests samples of all materials used in the building of Caterpillar products. Included in the testing are such materials as forgings, castings, bar stock, tubing and ferrous metals, as well as bronze, aluminum, brass of the non-ferrous group. Rubber, cork, plastics, paints, oils, solvents, chemicals and fibers receive extensive examination. Tests also are run on structural steel and concrete used in building plant facilities.

Working under the direction of the Peoria plant metallurgists are metallurgical, chemical, and welding staff engineers who evaluate new materials, establish testing techniques, prescribe specifications, help solve manufacturing problems, and develop new applications.

Another group, the heat treat engineering staff, has the important job of initiating the planning and scheduling of all instructions for production heat treat operations. This group designates tooling and equipment for all phases of production heat treatment. This responsibility includes not only making sure that heat treating operations are properly maintained and controlled but that techniques and applications to process new parts and improve existing parts are created.

The metallurgical and materials division's facilities actually contain a number of specialized laboratories. Evaluation of a supplier's product, tested in one or more of these stations, determines whether the material will be accepted or rejected.

In the physical testing laboratory, for example, all ferrous and non-ferrous metals purchased by Caterpillar are tested. Tests are made to determine hardness, ability to withstand impact, tensile strength, and other qualities necessary to meet Caterpillar standards. All steel, whether in prefabricated or piece part form, is tested in all phases of processing. High premium steels are pre-tested from samples submitted by steel mills. Techniques and methods of testing are also developed for use by receiving inspection personnel.

Photography also plays an important role in metallurgy and the new laboratory is equipped to do both color and black and white photographic processing. Photomicrographs (photos of surfaces or cross-sections of metals magnified many times) are taken, developed, and printed. Metallurgical operations also are photographed for study, and prints become part of report data.

The spectrograph and quantometer incorporate a modern and efficient method of making chemical evaluations of steel. An electric arc is applied to a metal sample to produce a white light. A prism within the spectrometer breaks down this light into the colors of the spectrum and permits an extremely accurate analysis of elements present and their amounts in the metal sample. The spectrograph records photographically all the elements in the sample and the quantometer records them directly on graph paper.

The weld testing laboratory evaluates new welding products and methods as well as improving on present methods and processes. Ultrasonic testing is used to establish weld soundness. Using equipment similar in principle to radar or sonar, sound waves are used to check defects in metal parts and weldments.

Even a material as ordinary as concrete interests the metallurgical and materials division. In the concrete laboratory, concrete used in building construction or repair is given a thorough testing to determine its compressive strength.

All materials not submitted to spectroscopic analysis are checked in the chemistry laboratory. Spectroscopy standards are checked here as well. Within this area is a control group, which directs the control of chemical processes in manufacturing. This group serves as a control center for the development and improvement of such processes as electro-plating, phosphate pickling, wash tank solutions, rust preventives, machine coolants, and heat treat solutions. ★ ★ ★

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Supervisory Control of Gas Pipelines

ABOUT the first thing that pipeline management must decide about push-button-operated pipelines is whether they wish to try it at all. They must weigh the advantages of reduced operating personnel and increased efficiency of the remaining men against the installation cost of control equipment and the additional safety precautions required, with the resulting risk of down time of remotely controlled compressor stations.

This means that such installations must be examined on a case-by-case basis.

Pushbutton operation will be indicated for a majority of systems, at least to some extent, and assuming that management desires to go that route, the next step is to decide whether to control the entire line and all the compressor stations from a central point or divide the system into two or more control sections.

There are advantages to either choice, but I wish to emphasize that in either case it is desirable to transmit or telemeter certain vital dispatching information such as pressures and flow to one central office in order that the entire pipeline operation can be observed and appropriate dispatching instructions issued.

If the line is sectionalized for remote-control purposes, the control centers will receive instructions from the central dispatch office, and through their pushbutton facilities control the stations within their jurisdiction. Each section is complete within itself, and, as far as physical control is concerned, might be considered an independent pipeline.

Paper presented before ASME Petroleum Mechanical Engineering Conference, Tulsa, Oklahoma, September 22-25, 1957.

Advantages of Sectionalization

Advantages of this type of operation is that long communication circuits for control use are not required and the control personnel of each section are nearer to and in closer contact with the stations under their control. Personnel stationed at these control centers also can act as back-up for emergencies that might occur within their area. Proceeding further, it may be inadvisable, for economic or operational reasons, to remove all personnel from certain compressor stations, and these points might well be chosen to act as control centers for one or more stations adjacent to them. This is particularly true if it is desired to concentrate personnel at the larger reciprocating powered stations, and have them control electric or turbine-powered stations adjacent to them.

Adequate communication channels are required between the central dispatch office and each of the section control points and may consist of voice or teletype circuits.

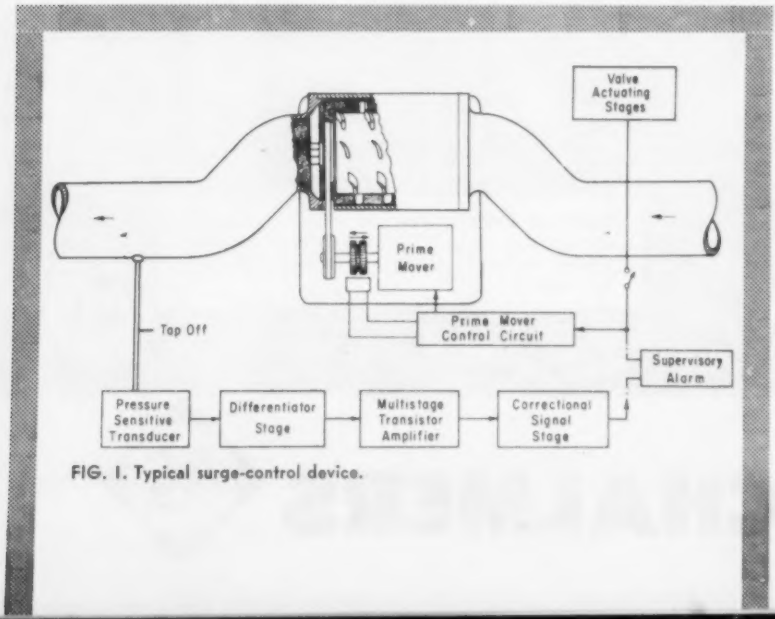

FIG. 1. Typical surge-control device.

The advantage of controlling the entire system from a central point at the present time is largely confined to reduction of control personnel. This condition will hold true until the advent of the "automatic pipeline."

At this time I would like to make clear that, although we hear a lot of discussion about automation of pipelines, there are no automatic pipelines in operation today. An "automatic pipeline" is one that operates without human supervision, from a previously programmed set of instructions. "Automation" of pipelines requires the use of feedback in the control system and we just do not have the facilities at this time.

Automation of pipelines requires a knowledge and use of the art of cybernetics, and its reduction to control simple things such as valve control and compressor speed.

Equipment for automation is rapidly becoming available and it is only a matter of time before some company places onstream the first fully automatic pipeline.

Equipment and control facilities are now available for efficient supervisory control of a manual or non-automatic control system and the two choices of operation have been outlined.

Compressor Station Safeguards

With either choice, certain safeguards are required for compressor station operation and just this year one of the larger gas pipelines developed a device that will reduce the compressor surge hazard that can develop at centrifugal-blower-type stations. Such protection is an absolute necessity at unattended stations.

Pipelines can be designed so that the centrifugal compressors operate at the noncritical portion of their efficiency curve, but no amount of designing can eliminate abnormal pipeline pack and flow conditions, which inadvertently will change these optimum operating conditions. You probably can design centrifugal compressors so it would be almost impossible for them to surge, but by so doing you would sacrifice efficiency, and sacrificed efficiency means increased dollars for power bills to run them. So it is economical to try for highest efficiency and provide surge

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protection for the few times that abnormal conditions occur.

This surge-control device uses the feedback principle of control whereby a transducer watches the pressure variations at the discharge side of the station and transmits this to a device that goes into operation if this pressure starts to oscillate or surge and takes steps to control or eliminate the surge condition. This is done by gradually opening a recirculating or by-pass valve to give the compressor more load, in the case of an electrical constant-speed unit, or in some cases reducing the speed of a turbine or other variable-speed drive if such is used. Ordered changes in pressure or transient blips will be observed but will not trigger the device. It will be noted that it is designed to keep the station on the line if at all possible while corrective action is taken. It also will permit the station to remain safely on the line even in the critical range of compressor operation, whereas without such a protective device it would be necessary to play safe and take it off the line.

In some cases this device may be used to detect a presurge or critical operating condition and transmit this warning to the control center so that remedial action can be taken before an actual surge occurs.

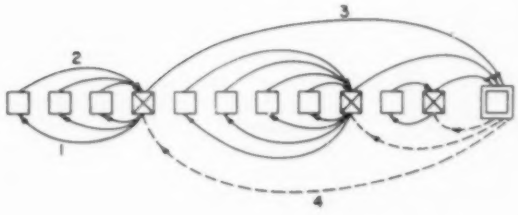
Installation of a typical surge-control device is shown in Fig. 1.

A typical sectionalized control system is shown in Fig. 2. It will be noted that no actual operating information is transmitted beyond the section control center except pressures and possibly blower speed.

If all control is centered in one point, a typical installation is shown in Fig. 3. Note that all information that might be transmitted to the section control points must now be sent to the master control center. This may require several communication channels, particularly if continuous telemetering is required, but the cost of these channels is balanced by the reduction of control personnel.

Future Automatic Pipeline

Although its operation is not a part of this paper, a typical future automatic pipeline layout is shown in Fig. 4. Note the "closed-circuit" operation, with feedback loops from gathering and



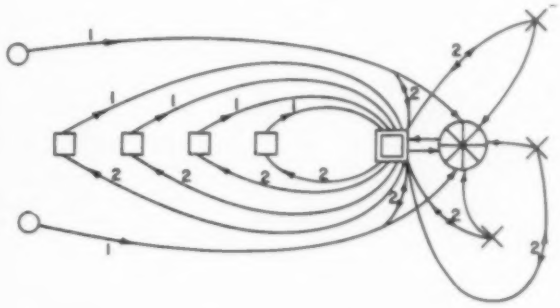
1. SUPERVISORY CONTROL CHANNELS
2. TELEMETERING CHANNELS
3. TELEMETERING CHANNELS (PRESSURES ONLY, FROM ALL STATIONS) CONTINUOUS & RECORDED

□ SATELLITE OR CONTROLLED STATION

⊠ CONTROL CENTER

▣ DISPATCH CENTER

FIG. 2. Typical sectionalized control system.



1. TELEMETERING CHANNELS
2. CONTROL CHANNELS

□ SATELLITE OR CONTROLLED STATION

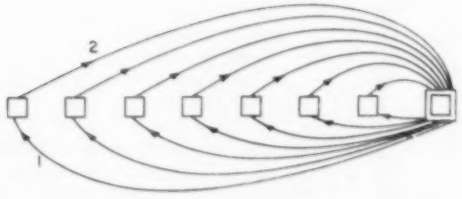
▣ CENTRAL DISPATCH & CONTROL COMPUTING POINT

✳ COMPUTER

○ SALES OR DELIVERY POINT

× PURCHASE OR GATHERING POINT

FIG. 4. Typical "automatic pipeline."

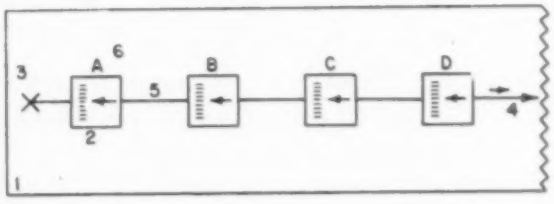


1. SUPERVISORY CONTROL FUNCTIONS, (CHANNELS)
2. TELEMETERING CHANNELS, CONTINUOUS & ON-CALL

□ SATELLITE OR CONTROLLED STATIONS

▣ DISPATCH & CENTRAL CONTROL CENTER

FIG. 3. Typical centralized control system.



1. WALL DISPLAY BOARD
2. RECORDING STRIP METER
3. GATHERING POINT
4. DELIVERY POINT
5. INDICATED PIPE LINE
6. COMPRESSOR STATION SITE

FIG. 5. Visual display board at central dispatch point.

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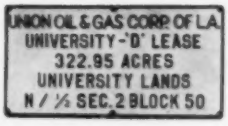
Marker Vent With Built-In Junction Box

Aerial Marker

Cap Marker



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sales points, through a computer into the device.

The number of alarm and control functions transmitted between the control center and the controlled station will vary considerably, both as to type of compressor station involved and the desires of the company that operates them. In general, the stations should have automatic operation within themselves as much as possible, with sequencing controls so that they may be started or shutdown by means of one supervisory function. This automatic sequencing is quite simple on electric-motor-drive stations, more involved with turbine drive, and quite complicated with reciprocating-engine drive. Fortunately, the turbine powered stations are pretty well equipped for remote-control use, and some of the latest reciprocating-engine-driven stations are being installed with remote operation in mind.

Conversion to remote control of the older reciprocating-engine-driven stations is quite expensive. This is due to the problem of adding various controls and valves to an existing station; the actual supervisory control equipment cost is not excessive.

For this reason, it is sometimes better to keep personnel at the reciprocating stations, and have these men control any turbine or electric stations that are adjacent to them.

Control and Telemetering

It is outside the scope of this paper to outline the various steps involved in sequential control operation within a station. Examples of control and telemetering functions are listed, however, that would be typical of the requirements for remote operation of a compressor station. This list does not include control of gathering-line or delivery-point valves.

All Type Stations

Telemetered information and control functions:

1. Suction and discharge pressures are transmitted to each section control center, and in addition to the central dispatch office on a continuous and recorded basis.
2. High-gas-pressure alarm.
3. Gas-leak alarm.
4. Gas temperature; on call basis.
5. Surge detector or near-surge condition alarm (centrifugal compressors only).
6. Unit shutdown alarm.
7. Emergency station shutdown alarm.
8. Compressor speed (if indicated).
9. Abnormal condition alarm.
10. Compressor start and stop.
11. Open and close station by-pass valve (optional).

Telemetering and control required

by induction or synchronous-motor-driven centrifugal compressor stations.

1. Individual motor kw load. On call.
2. Total station kw load. On call.
3. Compressor guide-vane position. On call.
4. Station-demand alarm. To indicate when demand is approaching maximum set point.
5. Unit shutdown alarm.
6. Station shutdown alarm.
7. Main power-loss alarm.
8. Abnormal condition alarm.
9. Guide-vane adjust control.

Reciprocating units additional functions:

1. Speed controller.
2. Shutdown plus lockout alarm.

Gas-turbine units additional functions:

1. Load turbine-speed controller.
2. Telemeter load-shaft speed for each unit. On call.
3. Telemeter axial compressor shaft speed each unit. On call.

Information at Dispatch Center

The dispatch center, whether or not the control system is sectionalized, should receive complete information on the pack and flow of gas. This should include not only all compressor station points but information on volume of received gas from gathering points and volume delivered to various sales points along the line. Only then can an accurate picture be observed of true line condition.

This information should be recorded continuously, and some day it will be used also for accounting purposes.

It is believed that gas lines might take a look at the methods employed by some products lines, and employ a visual indication of the state of the line. This could be done by employing a wall-mounted display board, which would show the pipeline plus compressors, gathering, and delivery points. Lights would show the stations in operation and in some cases meters would indicate the engine speed or other pertinent information.

The continuous recorders would be of the strip type, and mounted horizontally so that the recording needle, at optimum operating pressures, normally would fall in a position identical to the line designated as the pipeline on the operating board. If the pressure rose above this optimum point, or dropped below it, the indicating needle would vary above or below the indicated pipeline and the pressure status of the entire line would be observed at a glance. A form of this visual presentation board is shown in Fig. 5.

This method of presentation could be amplified so that the visual display

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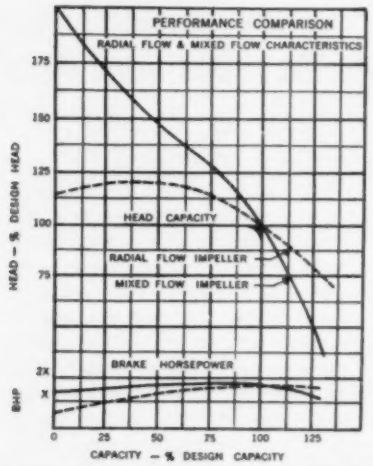

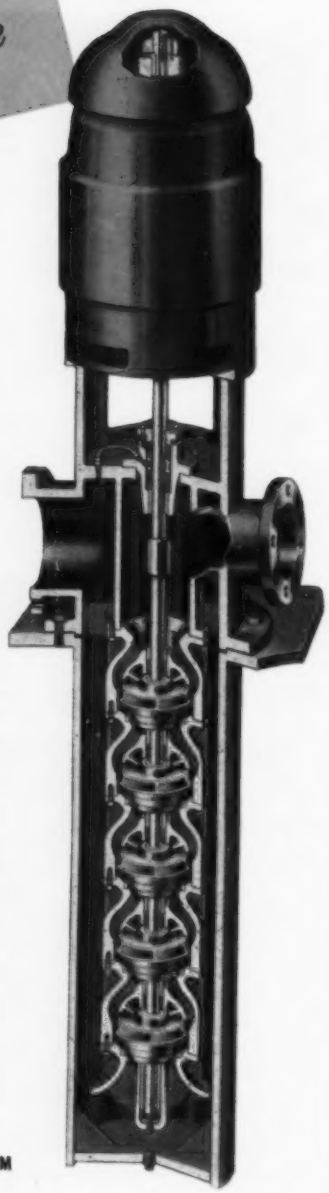

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board would be a translucent material, with the pipeline position and other data inked or etched in, and the pressure indications indicated on, above, or below this line by means of a spot of light from the recording meter, which would shine through the translucent board. This information at a later date could be absorbed by computers that in turn would issue optimum operating instructions for the pipeline.

All this would release personnel from locally tending compressors and changing valve settings and meter charts and figuring up optimum rates of flow, and give them more time to think, and to operate the line at utmost efficiency.

Types of Systems

There are several suppliers of supervisory control equipment for pipeline use and all of them are good. In general, if long communication circuits are required, it is well to investigate the several types of complex coding techniques available, which tend to eliminate malfunctions due to noise or "static" on the channel.

These systems are divided into two groups, one of which uses a narrow band or telegraph-type communication channel, and the other a wider-band voice type channel. Continuous telemetering requires a tone for each function, and usually is obtained by using a voice-type channel, which can be divided into several control and telemetering functions.

The automatic pipeline will require some form of continuous telemetering to provide continuous feedback information to the master control center.

Whether this will be in the form of analog slide-rule information or digital typewritten data is largely conjecture at this time. The author cannot help but visualize a computer arrangement with smoothly variable values of flow and demand acting as forces on the mechanical brain, which interprets them and issues instructions to the pipeline control mechanism.

It should be brought out that the digital technique of information transmission just now hitting the pipelines is the result of military requirements brought on by missile control. The target seeking or self-guided missile, I believe, uses analog techniques of control and is truly an "automatic pipeline" type of operation.

In conclusion, I would like to say that for a variety of reasons the gas pipelines as a group have been somewhat hesitant to go into the supervisory-controlled pipeline business. However, reduced operating costs and more efficient line operation will surely convince more and more managements that supervisory control of gas pipelines is here to stay. ★ ★ ★

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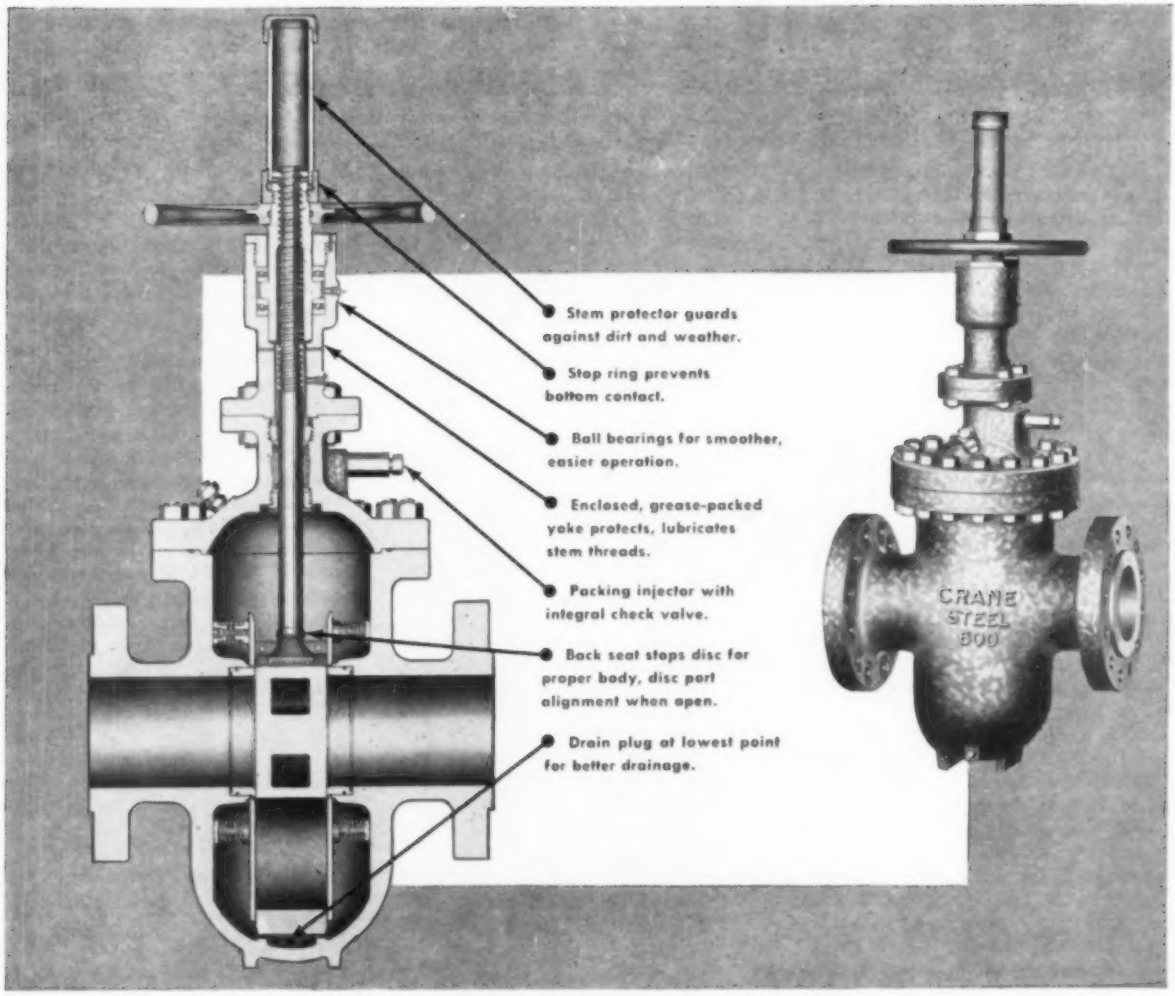
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Pipeline Projects

Plans for $182 Million Gas Facilities Approved

A Federal Power Commission presiding examiner has filed a decision, subject to review by the Commission, authorizing five companies to construct facilities having a combined estimated cost of nearly $182,000,000. The facilities will make available an additional 485,000,000 cu ft of natural gas per day to market areas in the Midwest, principally the Chicago area.

The decision, by Presiding Examiner Glen R. Law, grants certificates to Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company, and Chicago District Pipeline Company, all of Chicago; Pacific Northwest Pipeline Corporation, of Salt Lake City, Utah, and Colorado Interstate Gas Company, of Colorado Springs. The applications of the five companies are interdependent, forming primarily a unified proposal to make available additional natural gas supplies to the Chicago area.

The presiding examiner's decision, among other things, authorizes Pacific Northwest to sell natural gas to Colorado Interstate, which in turn will make sales to Natural Gas Pipeline Company. Natural, Texas Illinois, and Chicago District—all affiliates in the Peoples Gas Light and Coke Company system—are operated as a single integrated system primarily supplying gas for ultimate consumption in Chicago and adjacent areas of northern Illinois and Indiana.

Natural's project, estimated to cost $76,199,000 includes the construction of 415.7 miles of 36-in. loop line between Beatrice, Nebraska, and Joliet, Illinois, to increase its system capacity by 450,000,000 cu ft daily. Project also includes the supercharging of 86 main line compressor engines at stations in Oklahoma, Kansas, Nebraska, Iowa, and Illinois. This portion of the project, for which the company received temporary authorization last April, is designed to add 35,000,000 cu ft per day of additional sales capacity.

Chicago District proposes to build facilities to increase its system capacity by 456,000,000 cu ft per day. Project includes construction of approximately 52 miles of 36 and 30-in. loop lines between Joliet and Chicago. Estimated cost of the project is $13,000,000.

Colorado Interstate will build a total of more than 700 miles of pipeline and install 60,980 hp in new and existing compressor stations at an estimated cost of approximately $86,934,900. New facilities will be in Colorado, Oklahoma, and Kansas, and in part will replace old facilities that will be retired.

Pacific Northwest will construct facilities, estimated to cost $5,757,750, to enable it to sell 117,500,000 cu ft of gas per day to Colorado Interstate. Pacific Northwest's project includes installation of 22,500 hp in existing compressor stations.

Two Orders Grant Ohio Fuel Right to Build

The Federal Power Commission has granted final authority to Ohio Fuel Gas Company to construct and operate 33 miles of pipeline, varying in diameter from 4 to 20 in. The new lines will be laid in Lorain, Belmont, Guernsey, Champaign, Logan, Greene, Clark, Madison, Fayette, Licking, and Richland counties. FPC also authorized abandonment of 33.9 miles of 12-in. pipeline, which will be replaced by the new facilities.

Temporary authorization had been given for the new work on September 6.

In another order temporary authority was given for construction of 21.8 miles of 12 and 20-in. line in Montgomery, Holmes, Wayne, Stark, Carroll, Morrow, and Marion counties.

Cities Service to Replace Old Lines in Kansas

The Federal Power Commission has granted Cities Service Gas Company temporary authorization to construct, operate, and replace natural gas facilities in Kansas.

Cities Service proposes to construct 41 miles of 30-in. line from the Verdigris River to the Petrolia compressor station; 33 miles of 30-in. between the Petrolia and Welda compressor stations; 4 miles of 4-in. in Wilson County, and 6 miles of 12-in. in Reno County.

Facilities to be reclaimed consist of two 16-in. lines totaling 76.53 miles and 0.54 mile of 18-in. line between the Verdigris River and the Petrolia station; two 16-in. lines totaling 65.34 miles between the Petrolia and Welda stations, and 6 miles of 8-in. line in Reno County. These facilities will be replaced by proposed construction.

Cost of constructing the new facilities is estimated at about $5,902,000. Cost for reclaiming the existing facilities is estimated at approximately $550,500.

Examiner Gives Transco OK for $50 Million Project

A Federal Power Commission presiding examiner has filed a decision, subject to review by the commission, authorizing Transcontinental Gas Pipe Line Corporation, to construct and operate natural gas facilities estimated to cost $53,714,000.

Presiding Examiner Emery J. Woodall also authorized Eastern Shore Natural Gas Company, of Salisbury, Maryland, to construct and operate approximately 124 miles of 8⅝ and 6⅝-in. transmission pipeline and appurtenant facilities at an estimated cost of about $3,025,000 to serve the eastern shore areas of Delaware and Maryland. Eastern Shore will receive gas from Transcontinental.

Transco proposes to construct its facilities in the states of Texas, Louisiana, Mississippi, Alabama, Georgia, South Carolina, Virginia, and Maryland, divided into two groups: (1) Those facilities proposed for construction north of compressor station No. 5 in Evangeline Parish, Louisiana, which Transco considers primarily as main line facilities; and (2) those facilities to be constructed south of station No. 5, which the company considers primarily as gas supply or purchase facilities.

Part 1 facilities include 112.62 miles of 36 and 30-in. main line loops; 12.84 miles of 24-in. Louisiana purchase lateral loop; 32,500 compressor hp in three new stations; 4000 additional hp at station No. 20; additional facilities at 11 existing stations; and seven new sales meter stations.

Part 2 facilities consist of 15.77 miles of 30-in. main line loops; 246.97 miles of 24 to 3-in. purchase laterals; 18,640 additional hp at three existing compressor stations; a new gas gathering meter station; eight new dehydration stations, and wellhead meters.

Shell to Lay Line at Least 100 Miles Long

Shell Pipe Line Corporation will construct a crude oil pipeline in southern Louisiana from Shell Oil Company's Southwest Pass terminal to the Norco refinery.

The line will be at least 100 miles long, according to company officials, and will be extended if others want to participate in the project. Until the number of participants is known the exact length, diameter, and capacity cannot be determined.

Qum-Turkey Pipeline Again in Limelight

The National Iranian Oil Company has signed an agreement with an American firm to build an oil pipeline from the Qum oil fields to Iskenderun, Turkey, on the Mediterranean Sea, according to announcement by the Shah of Iran. Although not named by the Shah, the American company is reported to be the New York investment house of Allen and Company.

The pipeline would be approximately 1000 miles long.

The Shah said the American firm would assume $500,000,000 of the cost of constructing the pipeline. He did not say how much the Iranian government would invest. He did say, however, that Iran's share of the profits would be at least 75 percent, and considerably more if profits exceed a set minimum.

New Pipeline Will Provide Freer Products Movement

Clark Oil and Refining Corporation, Chicago, has announced plans to build a 15-mile pipeline from the company's refinery at Blue Island to the Indiana Harbor area on Lake Michigan. The line will be of 8-in. from Blue Island to a terminal site in Hammond, Indiana, and 12-in. from the terminal to connecting points with common carriers and to dock facilities on Lake Michigan.

Company tankers will be able to load at the deep water terminal instead of using the Calumet Sag Channel with its draft limitations as is the case now. The line also will enable the company's refined products to move directly into interstate common carrier products pipelines serving areas where the company has its retail markets.

Construction will begin early in 1958 and will be completed in about three months.

Equitable Would Develop Gas Storage Pool

An application by Equitable Gas Company, of Pittsburgh, Pennsylvania, seeking authority for the development of the Rhodes natural gas storage pool in Lewis County, West Virginia, has been accepted for filing, the Federal Power Commission announces.

Proposed development would include the construction of 11.7 miles of storage pipeline, drilling of 40 wells, construction of a dehydration plant and the alteration of piping at the existing Skin Creek compressor station. Cost of the proposed development is estimated at about $2,091,430. Salvage of existing equipment is estimated to amount to approximately $20,000.

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Projects

El Paso Application Accepted for Filing

An application by El Paso Natural Gas Company, of El Paso, Texas, seeking authorization for the construction and operation of natural gas facilities during 1957, at a cost not in excess of $5,000,000, has been accepted for filing, the Federal Power Commission announces.

El Paso proposes to construct 4½ to 20-in. field lateral lines, each single project not to exceed $500,000 and the aggregate cost not to exceed $1,500,000; compressor facilities varying in size from 300 to 1600 hp, each single installation not in excess of $500,000 and the aggregate cost not in excess of $1,500,000; purification and/or dehydration and appurtenant facilities, each single installation to cost not more than $500,000 and the aggregate cost of such facilities not to exceed $1,000,000, and additions and alterations to existing gasoline plants, each installation not to cost more than $500,000 and the aggregate cost not to exceed $1,000,000.

El Paso's application stated that the purpose of the additional facilities is to attach new supplies of gas from independent producers in the general area of its existing transmission system, where expansion of its overall facilities are not involved.

Ohio and West Virginia Construction Approved

The Federal Power Commission has granted The Manufacturers Light and Heat Company, of Pittsburgh, Pennsylvania, temporary authority to construct and operate natural gas facilities in Ohio and West Virginia at an estimated cost of approximately $757,300.

The proposed facilities consist of 2.56 miles of 12-in. transmission line from Wellsville to a point in Saline Township, Ohio; 7.64 miles of 12-in. transmission line in Brook County, West Virginia, and 3.55 miles of 10-in. transmission line in Ohio County, West Virginia, near Wheeling.

In connection with the proposed construction, Manufacturers has also requested FPC authorization to abandon about 12 miles of various diameter transmission pipeline to be replaced by the new facilities. Approximately 9.4 miles of the abandoned transmission lines would be retained as distribution lines.

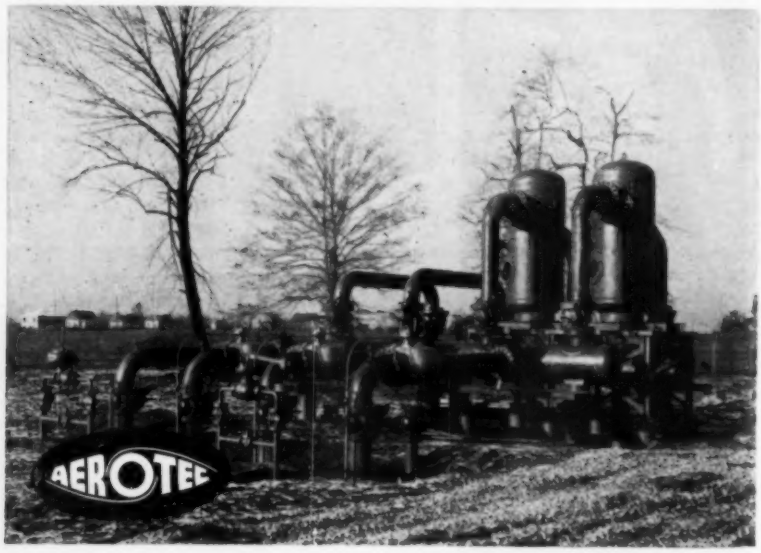
Operating Authority Given Texas Eastern

FPC Presiding Examiner Emery J. Woodall has filed a decision, subject to review by the commission, authorizing Texas Eastern Transmission Corporation and Texas Eastern Penn-Jersey Transmission Corporation to construct and operate natural gas pipeline facilities, and also authorizing the sale of additional natural gas by Algonquin Gas Transmission Company.

The presiding examiner authorized Texas Eastern to construct about 96.5 miles of 30-in. loop pipeline between Kosciusko, Mississippi, and Uniontown, Pennsylvania; about 9.4 miles of supply laterals; a new 10,250 hp compressor station, and to add 33,360 hp to existing compressor stations and related metering and appurtenant facilities. Cost of these facilities is estimated at approximately $24,599,000.

Penn-Jersey was authorized to add 24,000 compressor hp to existing stations on its pipeline system extending from Westmoreland County, Pennsylvania, to Texas Eastern's compressor station No. 26, near Lambertville, New Jersey. Estimated cost of Penn-Jersey's additions is about $4,417,800. These facilities will be leased and operated by Texas Eastern.

The FPC, on June 12, granted Texas Eastern and Penn-Jersey temporary authorization to construct the additional facilities but did not authorize their operation.



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GAS TRANSMISSION LINE

The development of the Aerotec Dry Gas Scrubber several years ago provided the First Scrubber to assure clean gas with no carry-over of liquids or solids.

Multiple small-diameter cyclone tubes create a high centrifugal force, resulting in the removal of solids and liquids without the use of wetting agents. The result is a dry, clean product.

This principle assures high efficiency, and continuous discharge of contaminants with no pressure build-up.

Since the installation of the first Aerotec Scrubber, a continuous program of research and development has produced several new and outstanding design and applications of this principle. Our Project Engineers, with years of experience in this field, will be glad to help you in working out your problems. Why not contact them today?

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520 TRENCHLINER®

Here's the Big-Inch 520 in action on a 650-mile, 30-inch pipeline in the natural gas fields of Northwest Canada. Experience on isolated, cross-country jobs like this has proved the 520's performance under toughest conditions of materials and terrain.

New 170 wide-wheel Trenchliner digs 20 to 32 inches wide, 5¾ feet deep. It has hydraulic wheel-hoist on power-tilt mast. Conveyor is hydraulically driven — belt speeds are independent of digging wheel speeds. Big Parsons line includes all sizes of trenchers — wheel-types, ladder-types — on crawlers, and rubber tires.

BIG THINGS HAVE HAPPENED since you last looked at big, wheel-type ditchers. New sizes have been added to Parsons line. First, meet the Big-Inch 520 Trenchliner — shown above. This wheel-type 520 digs 8½ feet deep, 40 to 52 inches wide — opens cross-country lines at speeds up to 28 lineal feet of trench per minute. And that's not all —

Also, a MIDDLE-INCH 420

Another big-wheel machine has joined the Trenchliner team — a Middle-Inch 420. It gives you digging depths to 7½ feet. Trench widths range from 31 to 46 inches. Depending on depths, widths, and job conditions, the 420 Trenchliner digs up to 44 lineal feet per minute.

Both of these big, wheel-type Inchers have been thoroughly job-proved. They were originally developed by C-R-C, and now built by Parsons — bringing you the *combined* engineering know-how and services of both firms. Call us next time you're in the market for a big ditcher.

PARSONS COMPANY • Newton, Iowa

DIVISION OF KOEHRING COMPANY

PT-97-REV

TRENCHLINERS for PIPELINERS

WITH THE PIPELINE CONTRACTORS

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 100 miles of 18-in. for *Alberta Gas Trunk Line Company, Ltd.*, from Burstall at the Alberta border to Provost, Alberta. Also has 22 miles of gas gathering line in the Provost field for *Provo Gas Producers, Ltd.*, consisting of constructing gathering system and wellhead tie-ins—3 to 12-in. pipe; this gas to be fed to Alberta Gas Trunk Lines.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Has contract for construction of transmission and distribution system in the town of Wilkie, Saskatchewan, for the *Saskatchewan Power Corporation*.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 miles 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 71 miles of 30-in. line for *Texas Eastern Transmission Corporation* in the Port Lavaca, Texas, area. Has contract for construction of 343 miles of 30-in. pipeline loops for same company, consisting of six jobs in Tennessee, Kentucky and Ohio.

● **Sheehan Pipe Line Construction Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 116 miles of 8-in. line for *Buckeye Pipe Line Company* between Huntington and Griffith, Indiana; project includes take-up, reconditioning and relay. Also has 70 miles of 8-in. line to recondition for *Buckeye Pipeline Company* near Cooks Ferry, Ohio.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has 150 miles of gathering lines in northern Alberta and British Columbia for *Westcoast Transmission Company, Ltd.*

● **Troth Construction Company, Box 592, Britton, Oklahoma.** Has contract for 160 miles of 2 and 8-in. lines for gas distribution to communities in the Aberdeen, South Dakota, area, for *Northern Natural Gas Company*.

● **Engineers Limited Pipeline Company, 200 Bush Street, San Francisco, California.** Has line for *Pacific Gas & Electric Company* consisting of 37 miles of 20-in., 37 miles of 18-in., and 19 miles of 12-in. to lay from Beehive Bend field to Sacramento, California.

● **Mannix Company, Ltd., 332 Seventh Avenue W., Calgary, Alberta.** Has 160 miles of 3 and 6-in. gathering line to lay in the Pembina field for *Pembina Pipeline, Ltd.* Has contract to lay 12 miles of 4-in. gathering line in the Drumkeller East field for *Pembina Pipeline*. Has four Gunite river crossings on the North Thompson River at Gosnell and Blue River, British Columbia, for *Trans Mountain Pipe Line Company, Ltd.*

● **F. E. Shaw, Ltd., 530 S. Vidal Street, Sarnia, Ontario.** Has 40 miles of 6 to 10-in. line for *Dominion Natural Gas Company, Ltd.*, in the Brantford, St. Catharines, and St. Thomas districts. Has 8 miles of 16-in. line for *Dow Chemical of Canada, Ltd.*, from new salt bed location to the Sarnia district. Has 14 miles of 16-in. loop line around the city of Hamilton, Ontario, for *United Gas and Fuel Company*. Has 67 miles of 6 to 20-in. transmission lines for *Union Gas Company*, Chatam, Ontario, to Dawn, London, St. Marys, Stratford, Kitchener and Guelph.

● **Engineering-Construction Company, First National Bank Building, Tulsa, Oklahoma.** Has contract with *City of Macon, Missouri*, to lay 25 miles of 4 and 6-in. between Moberly and Macon, Missouri, and 12 miles of various size distribution lines in Macon.

● **C. P. Bartley & Son Pipe Line Construction, P. O. Box 616, Tioga, North Dakota.** Has 121 miles of 2 through 12-in. gas gathering extensions for *Signal Oil & Gas Company* in the Newton, North Dakota, area.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 80 miles of 30-in. gas line for *Texas Eastern* from Kosciusko to Egypt, Mississippi. Has 80 miles of 30-in. natural gas line for *Northern Ontario Pipe Line Crown Corporation* between Uspala and Port Arthur, Ontario. Also has 33 miles of 6, 8, and 10-in. lateral gas lines for *Tennessee Gas Transmission Company* in the vicinity of Southwest Pass below New Orleans, Louisiana. Has 20 miles of 18-in. natural gas line reconditioning for *Texas Gas Transmission Corporation* near Bastrop, Louisiana.

● **Dutton-Williams Brothers, Ltd., North Canadian Oil Building, Calgary, Alberta.** Has 60 miles of 30-in. natural gas line from Kenora, Ontario, eastward for *Northern Ontario Pipe Line Crown Corporation*. Has 120 miles of 30-in. line for *Trans-Canada Pipe Line Ltd.*

● **Fish Service Corporation, M & M Building, Houston, Texas.** Has 67 miles of line for *Florida Pipeline and Storage Company* from Port Everglades to Homestead Air Force Base, Florida.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has sections 3, 5 and 6 of *Four Corners Pipe Line Company* line. Section 3 is a 16-in. line 98 miles long from Cameron to Seligman, Arizona; this work began July 1. Sections 5 and 6 are to begin October 15 to avoid crossing desert during hot summer. Section 5 is 105 miles of 16-in. line from the Colorado River to Twentynine Palms, California and Section 6 is a 46-mile 16-in. section from Twentynine Palms to Olive, California. Also has contract for underground crossing of Colorado River north of Needles, California, on the same line.

● **Dunn Bros., Inc., 801 Mercantile Securities Bldg., Dallas, Texas.** Has stringing contract with H. C. Price Company on 69 miles of 12-in. line for *Texas Eastern Transmission Company* between Chicago and Ashton, Illinois. Also has similar contract with same companies for stringing approximately 230 miles of 30-in. in Alabama, Tennessee, and Kentucky. Is stringing 32.5 miles of 30-in. for *Tennessee Gas Transmission Corporation* between Winchester and Richmond, Kentucky. Is stringing 76.5 miles of 16-in. between Aneth, Utah, and Kayenta, Arizona, and 86 miles of 12-in. between the Mesa station in Utah and the Bisti oil field in New Mexico for the *Four Corners Pipeline Company* (the A. P. V. Company is prime contractor). Will string 27.5 miles of 34-in. near Leupp, Arizona, for *El Paso Natural Gas Company*. Will string 85 miles of 14-in. between Columbus and Lebanon, Indiana, for *Texas Eastern Transmission Corporation* (H. L. Gentry is prime contractor). Also has 93 miles of 14-in. between Lebanon and Schnieder, Indiana, for the same company with Latex Construction Company acting as prime contractor.

● **G.E.T. Construction, Inc., 435 S. 116th St., Milwaukee, Wisconsin.** Has 46 miles of 24-in. loops in Wisconsin and Illinois for *Michigan Wisconsin Pipe Line Company*.

● **Hunsaker Trucking Contractor Inc., P. O. Box 97, Carrollton, Texas.** Has subcontract for H. B. Zachary Company 42 miles of 16-in. line between DeLeon and Baird, Texas. Has stringing contract for 20 miles of 12-in. between Sonora and Eldorado, Texas for *Pioneer Natural Gas Company*.

● **Potashnick Construction Company, Box 423, Cape Girardeau, Missouri.** Has joint venture with A. P. Vaughn Construction Company to lay sections 1 and 2 of *Four Corners Pipe Line Company* crude line between Utah and California. Both sections are 16-in. pipe; Section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; Section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work on both sections began June 15.

● **Oklahoma Pipe Line Constructors, P. O. Box 13227, Dallas 20, Texas.** Has 35 miles of 30-in. for *Tennessee Gas Transmission Company* between a point in Garrard County, Kentucky, to a point of TGT's compressor site in Powell, Kentucky. Also has 85 miles of 20 and 24-in. (spread 101) of *Trans-Canada Pipe Lines, Ltd.*, on the eastern section, in proximity of Toronto, Ontario, beginning from a point southwest of Toronto circling the city, and also a section beginning at a point east or northeast of Toronto.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has an 82-mile 30-in. spread for *Trans-Canada Pipe Lines, Ltd.*, from St. Anne, Manitoba, to the Ontario border. Also has contract for testing 580 miles 34-in. of Trans-Canada line between Burnstall, Saskatchewan and Winnepeg, Manitoba. Has 62 miles of 20-in. line for *Interprovincial Pipeline, Ltd.*, between Sarnia and Port Credit, Ontario. Has contract for 4 to 12-in. gathering system for *Producers Pipeline, Ltd.*, in the Estavan, Saskatchewan area. Has city distribution system in Cooksville, Ontario, for *Consumers Gas Company* of Toronto. Also has city distribution system for Guelph, Ontario, for *Union Gas Company of Canada, Ltd.*

● **A. P. Vaughn Construction Company, Box 1144, Fort Worth, Texas.** Has joint venture with Potashnick Construction Company to lay sections 1 and 2 of the Utah to California crude line for *Four Corners Pipe Line Company*. Both sections are 16-in. pipe. Section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; Section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work began June 15.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 120 miles of 16-in. and 5 miles of 12-in. for *Magnolia Pipeline Company* from Midland to Abilene, Texas. Has 7.2 miles of 24-in. loops to lay for *Service Pipeline Company* in Will County, Illinois.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has 26 miles offshore trenching for the *CATC Group* from Grand Isle, Louisiana, to a point 26 miles out into the Gulf of Mexico. Marine Gathering Corporation is the prime contractor, and Collins is burying the line being laid by Marine Gathering's pipeline laying barge. Also has 12,000 ft of 24-in. for *Tennessee Gas Transmission Company*, with Pentzien, Inc., the prime contractor; job is three river crossings installed in a downstream catenary across the Mississippi River at Greenville, Mississippi. Has contract for dual crossing of 10-in. lines on Detroit River between Windsor, Canada and Detroit for *Canadian Brine Ltd.*

● **Price-Poole Pipeline Constructers of Canada (joint venture of H. C. Price of Canada Limited and Poole Construction Company, Ltd.), Rivers, Manitoba.** Has 99-mile section of 34-in. pipe to lay for *Trans-Canada Pipe Line Company* on a section of line in Manitoba Province extending eastward from the Assiniboine River near Miniota.

● **Williams-Austin Construction Corporation, 3322 Grant Building, Pittsburgh 19, Pennsylvania.** Has 50 miles of 10-in. for *Central Hudson Gas & Electric Company* between Kingston and Albany, New York. Also has 5.7 miles of 26-in. line for *Atlantic Seaboard Corporation* in Hardy and Grant counties, West Virginia.

● **Holder Construction Company, Box 1438, Snyder, Texas.** Has contract on 134 miles of 6-in. products line for *Trust Pipe Line Company* between Hawley and Wichita Falls, Texas.

● **Panama-Williams Corporation, 1418 Melrose Blvd., Houston, Texas.** Has 85 miles of 12-in. for *Ohio Oil Company* between Robinson and Champaign, Illinois. Also has 177 miles of various size line to lay in South Carolina for the *Carolina Gas Company*.

● **Western Pipe Line, Inc., 1011 San Jacinto, Austin 66, Texas.** Has 94 miles of 30-in. for *Northern Ontario Pipe Line Crown Corporation* between Hawk Lake and Hyndeman, Ontario. Has 55 miles of 14-in. for *Texas Eastern Transmission Corporation*, between Kankakee and Chicago, Illinois.

● **Panama Inc., 1418 Melrose Blvd., Houston, Texas.** Has contract for 362 miles of 16-in. for the *Texas-New Mexico Pipeline Company* from Jal, New Mexico, northwestward. Has 193 miles of 4 to 24-in. line in Mocane and Laverne, Oklahoma, fields for *Colorado Interstate Gas Company*.

● **Four Way Company, Farmington Hwy., Aztec, New Mexico.** Has contract to lay 16-in. line for *Texas-New Mexico Pipeline Company*, for a distance of 150 miles southeast from the Aneth field in Southeast Utah.

● **Lone Star Pipe Line Constructors, Inc., P. O. Box 13167, Dallas 20, Texas.** Has 83 miles of 16-in. for *Permian Basin Pipeline Company* between stations at El Dorado and Midland, Texas.

● **Western Construction Company, P. O. Box 798, Austin 64, Texas.** Has contract for 130 miles of 30 to 36-in. line for *Transcontinental Gas Pipe Line Corporation* in Pennsylvania, Virginia, North and South Carolina.

● **E. K. Aldridge & Sons, Inc., P. O. Box 1324, Athens, Georgia.** Has 60 miles of 4 to 34-in. to lay in the Chester, South Carolina, gas distribution system for the *Chester County Natural Gas Authority*. Also has contract with *Lamar County Gas District*, Vernon, Alabama, to lay 35 miles of gas transmission lines and 25 miles of distribution lines.

Gas Pipeline Revenues Up for 12-Month Period

Operating revenues of reporting natural gas pipeline companies totaled $169,771,692 in July 1957, and $2,252,116,183 for the 12-month period then ended. This represents an increase of 16.2 percent and 11 percent over revenues of $146,092,741 and $2,029,568,021 received in the like periods a year earlier, the Federal Power Commission reports.

Gas sales to other gas utilities for resale, the principal business of these companies, were 441,870,000,000 cu ft for the month, up 12.5 percent over July 1956. Sales to ultimate consumers during the month were 132,805,000,000 cu ft, an increase of 7.6 percent over July 1956.

For the respective 12-month periods ended July 1957 and 1956 sales to other gas utilities for resale were 6,234,803,000,000 and 5,740,283,000,000 cu ft and to ultimate consumers 1,495,697,000,000 and 1,417,348,000,000 cu ft. Respective percentage increases were 8.6 percent in sales for resale and 5.5 percent in sales to ultimate consumers.

Texas Company Building New Pipeline Terminal

A new pipeline terminal for The Texas Company is under construction on a 15-acre site at Youngstown, Ohio. The terminal will be an addition to the company's country-wide network of more than 2000 wholesale distributing plants. Products will be redistributed from the terminal to Youngstown and environs and to the adjacent Pennsylvania area.

The Youngstown Terminal, which will have a tankage capacity of 3,066,000 gal of petroleum products, is scheduled for completion next July.

Sun and World Tankers End Their Litigation

The following statement is jointly issued by Sun Oil Company and World Tankers Corporation:

"Sun Oil Company and World Tankers Corporation are happy to state that the sincere differences of opinion which had arisen between them and which led to litigation both in the United States and in England have been amicably resolved, and that they have resumed contractual relations on terms which are mutually satisfactory."

The WILKINSON LINE LOCATOR
PREVENTS COSTLY DAMAGE

Spots all sub surface pipes, cables, etc., and determines their depth accurately.

ETCHED CIRCUITRY: instead of hand wiring, insures uniformity and freedom from faulty soldering.

BATTERY TESTER: instantly indicates battery condition without removing batteries.

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PIPELINE PERSONALS

O. Q. Lomax, formerly president of Humble Pipe Line Company, has been elected director and special pipeline consultant of Sharman, Allen, Gay & Taylor, Inc.

Newly elected officers of Laurel Pipe Line Company are **W. J. Wilkins,** president; **R. D. Jackson Jr.,** vice president and secretary; **M. W. Ramsey,** vice president; **C. C. Johns,** assistant secretary; **D. M. Hughes,** assistant secretary, and **Peter Affeld,** assistant treasurer. Members of the board of directors include the new president, three directors representing Gulf Oil Corporation, **J. L. Irvin,** Jackson, and Ramsey; three representing Sinclair Pipe Line Company, **G. H. Giles, K. T. Feldman,** and **D. S. Purnell,** and two directors from The Texas Company, **F. M. Dawson** and **J. W. Emison.**

Clark H. Craft has been named chief engineer and **Ralph W. Howe** has been named superintendent of measurement for Texas Eastern Transmission Corporation's Little Big Inch division. Both have been serving as engineers in the company's natural gas division.

Frederick W. Fink has been named chief of the corrosion research division at Battelle Memorial Institute. He has specialized in corrosion studies since first joining the staff of the Columbus, Ohio, research center in 1938.

F. B. Neptune has been elected executive vice president and general manager and **D. A. Roach,** vice president, of Phillips Pipe Line Company, a wholly owned subsidiary of Phillips Petroleum Company. Neptune succeeds **M. O. Johnson** who was recently named manager of Phillips Petroleum Company's newly formed computing department. Neptune also was named manager of the newly created pipeline division of Phillips Petroleum Company's supply and transportation department. He was formerly manager of the products pipeline division of that department. Roach and **W. H. Wallace** have been made assistant managers of the new division. Roach had been chief engineer of the department's engineering division. Wallace was formerly manager of the crude oil pipeline division.

Four research scientists have been promoted to managers by Philco Corporation to advance the research efforts of its government and industrial division. They are: **J. Forrest Bigelow,** radar and radio systems; **F. J. Bingley,** audio-video data systems; **C. P. Woodward,** missiles and advanced tactical systems, and **Ralph Deutsch,** fundamental techniques.

Gulf Refining Company has announced the following new officers: **J. L. Irvin,** of Houston, Texas, president; **W. L. Shannon,** vice president; **M. W. Ramsey,** vice president; **G. W. Conrad,** comptroller-treasurer, and **Robert Carter,** secretary. Directors are Irvin, Shannon, Ramsey, **Walter Clemons,** and **S. O. Tostengard.**

Natural Gas Pipeline Company of America has announced five appointments affecting personnel at its Fritch, Texas, Beatrice, Nebraska, and Minneola, Kansas, locations. **T. R. Brennan** was named field superintendent of compressor stations (gathering system), and **J. E. Bullock** was named field superintendent of compressor stations (main line). In other appointments **L. L. Stallard** and **D. R. Wendele** were named superintendent and assistant superintendent, respectively, at Station 111, Fritch, and **C. J. Fitzgerald** was appointed superintendent of Station 103, Minneola. Brennan succeeds G. W. Gibbs, who died Aug. 8. He was field superintendent of main line stations with headquarters at Beatrice. Bullock, who succeeds Brennan was Fritch station superintendent. He will, however, supervise gathering system stations until sometime later this year, when he will take over his new position at Beatrice. Brennan's headquarters will be at Fritch. Stallard was assistant superintendent at the Fritch station and Wendele was superintendent at Minneola. Fitzgerald was in the compressor station division of the company's Chicago office.

G. J. Tankersley was elected president and a director of Western Kentucky Gas Company and its subsidiary. He was formerly executive vice president and a director of the Gas Light Company of Columbus, Georgia.

G. J. Tankersley

R. L. Anderson

Robert L. Anderson has been appointed representative of the pipeline market section, sales development division of Caterpillar Tractor Company. In his new position, he will be responsible for a program of market development for Caterpillar pipelaying crawler tractor models. He was a sales development special representative.

Henry P. Hellinghausen, manager of the material-traffic department of Interstate Oil Pipe Line Company of Shreveport, has been honored for his completion of 40 years' service with the company and a predecessor, Oklahoma Pipe Line Company. **P. H. Hunter,** Interstate president, presented a service emblem studded with three diamonds to Hellinghausen before friends and associates of the veteran pipeline employee at a meeting in the company conference room. He was commended by the president for "exceptional service to the company and substantial contributions to its progress" over his lengthy period of loyal service.

Robert D. Haack has been appointed superintendent of the new Standard Oil Company (Indiana) terminal at Escanaba, Michigan. Also announced was the appointment of two other terminal superintendents. **Earl R. Swett,** superintendent at Peoria, Illinois, since 1951, succeeds Haack as superintendent at the Milwaukee, Wisconsin, terminal, and **Dwight Browning,** district pipelines superintendent at Chicago since 1955, replaces Swett.

Several recent additions to the staff of Pipe Line Technologists, Inc. of Houston, have been announced. They are **Ralph C. Hughes Jr., Richard D. Hull** and **Richard S. Barfield** to the firm's specialized engineering staff and **William E. Neptune** to the newly created administrative position of assistant to the president. Hughes, formerly associate editor of *Pipe Line Industry* was with Sun Pipe Line Company for over eight years in various operating and engineering positions. Hull was with Sun Oil Company for eight years in engineering positions involving gas handling and processing. Barfield was with Gulf Refining Company for over seven years in pipeline design prior to joining Pipe Line Technologists. Neptune was with Texas Butadiene & Chemical Corp.

W. E. Brown, superintendent of compressor design engineering for Texas Gas Transmission Corporation, has retired after serving 50 years in the engineering field.

M. Wendell Ramsey has been appointed pipeline coordinator for the transportation department of Gulf Oil Corporation. He formerly served as coordinator, product pipelines.

John P. Dearasaugh of the Aluminum Company of America's Point Comfort operations has retired from active service. He has been with Alcoa for 37 years. At present Dearasaugh is vice president of Lavaca Pipe Line Company, a subsidiary of Alcoa. He has served in this capacity since 1949.

Alfred T. Krook has been elected vice president of Bechtel Corporation. He also has been elected to vice presidencies in Bechtel International Corporation and Canadian Bechtel Limited. Krook has been president and a director of Stone & Webster Canada Limited, Toronto, and a vice president of Stone & Webster Engineering Corporation, New York.

Clyde C. Copper has been named superintendent of measurement for Northern Natural Gas Company replacing **J. L. Griffin** who retired August 31 after 27 years' service with the gas transmission company. Copper has been assistant superintendent of measurement since 1948.

LPG Line to New York Studied by Railroads

The feasibility of a liquefied petroleum gas line from Houston, Texas, to New York City is being studied by the Katy and New York Central railroads. Williams Brothers Company, Tulsa, Oklahoma, are making a survey for the railroads to determine cost and other factors involved.

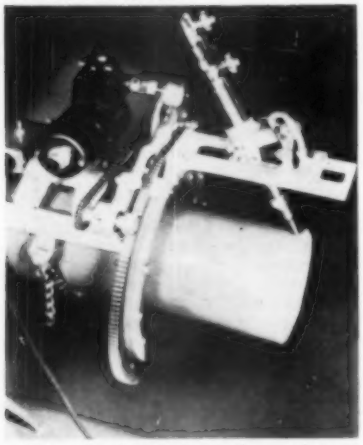
It would be a 2500-mile line, the longest LPG pipeline in the world. From Houston the route would be through Texas, eastern Oklahoma to Kansas City on the Katy right-of-way. From Kansas City to Paris, Illinois, New York Central's right-of-way would be used. From Paris the line would go to Cleveland and Akron, Ohio, with laterals to Pittsburgh and Buffalo-Syracuse area.

NEW Pipeline Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Motorized Unit. The H&M motorized unit provides completely automatic operation in cutting and beveling pipe, ranging in size from 1½ to 36 in. This unit can be attached to any one of H&M's 7 standard machines.



The motorized unit attachment is powered by a fractional horsepower ac-dc electric motor that is affixed to the machine by means of a mounting bracket. Switching from manual to automatic or vice-versa, is made easy by the quickly detachable mounting bracket. A flexible coupling is used to connect the motor with the crank pinion, which drives the main gear and the cutting torch around the pipe. *H&M Pipe Beveling Machine Company.*

Circle number (81) on reply card.

Welding Flux Developed. The Weldrod Department of Ampco Metal, has produced a new welding flux known as Ampco-BRaZ Flux No. 2 suitable for general brazing, cast-iron welding and cast-iron brazing with the oxy-acetylene process.

Several of the outstanding advantages are; (1) Excellent wettability, (2) nonfuming and non-toxic, (3) ability to depress filler metal bubbling and fuming, (4) deep penetration, providing strong joints, (5) protection against excessive oxidation, (6) dissolves and removes oxides formed, (7) provides dense, sound deposits, (8) easily removed from deposit. *Ampco Metal, Inc.*

Circle number (82) on reply card.

Whip Cable Plug. A quick means for attaching whip cables to lead cables is provided with the new Tweco whip cable plug just announced by Tweco Products, Inc.

The whip cable plug is used in combination with the BP-230 Tweco cable splicer. The splicer is attached to the lead cable by the use of the ball-point screw principle. The large area of contact, plus the extreme pressure of the screw, results in maximum electrical efficiency between parts. This connection stays tight under all conditions. A three-quarter turn of the ball-point screw will release the whip cable plug. *Tweco Products, Inc.*

Circle number (83) on reply card.

Automatic Flow Computer. The SIE Type DRF flow computer is a complete system, from transducer to printed record, for computing gas flow through an orifice. Using the AGA equation, all necessary corrections are introduced automatically, and results are visually indicated in analog or digital form. The accuracy is 1 percent of full scale under all operating conditions, however, greater accuracy may be obtained over a limited range in environments normally encountered. Power requirement is 80 w, 105-125 v ac 50-60 cps, single phase. *Southwestern Industrial Electronics Company.*

Circle number (84) on reply card.

All-Weather Cab. The J. Frank Sims Cab Company has announced the manufacture of a sturdy all-weather cab for use on International, Ford, Fordson Major, Case, Minneapolis-Moline, John Deere and Oliver tractors.

The cabs are designed to fit either the bare tractor, or tractors equipped with most combinations of front and rear-mounted equipment. Operating controls may be mounted inside the cab to allow full use of the tractor in all weather, the year around. The frame is constructed of rugged 12 and 14 gage steel and mounted to withstand vibrations and hard usage. *J. Frank Sims Cab Company.*

Circle number (85) on reply card.

Computer and Time Punch. Two new products which will greatly reduce paperwork drudgery for everybody have been introduced by International Business Machines. The products are: The IBM 610 Auto-Point Computer—a desk-side electronic computer about the size of a spinet piano—which can handle problems ranging from insurance premium computation to jet aircraft design, and the IBM 8200 Time Punch, which punches employee payroll and job cost data on IBM cards at the source of these operations—thereby permitting automatic accounting.

Both the 610 Computer and 8200 Time Punch represent another big step toward freeing engineers, scientists, and office personnel from monotonous and routine paperwork. These tools should also help reduce office costs by cutting through wasteful, time-consuming manual operations. *International Business Machines Corporation.*

Circle number (86) on reply card.

Data Automation System. Features of the new Univac II data automation system are described fully in an illustrated 79-page manual published by Remington. Foremost among the advanced features of the system is magnetic core storage that stores up to 120,000 characters, increased operating speeds, increased input-output capacity and speed, and greater programming flexibility.

A complete guide to the Univac II system, and designed for the needs of both the computer specialist and the layman, the manual contains five sections. Highlighting the versatility of Univac II is a 2-page fold-out diagram of the system and its peripheral equipment. *Remington Rand, Division of Sperry Rand Corporation.*

Circle number (87) on reply card.

Tank Gaging System. New advances in automatic liquid level measurement have been announced by Texas Instruments with the introduction of the Data-Gage, a tank gaging system to combine unlimited-distance, error-safe telemetering, power float accuracy of ± 1/16 in., and 100-tank capacity. The Data-Gage system consists of 3-compact and readily accessible units: receiver console, field selector unit and liquid level gage with power float. The Data-Gage is a true digital system employing digital code in binary decimal form. *Texas Instruments, Inc.*

Circle number (88) on reply card.

Line Of Motor Starters. A new line of 2300 to 4160 v starters (Type H) for full or reduced voltage starting, reversing or non-reversing, dynamic braking or multi-speed control of squirrel-cage, synchronous or wound rotor motors has been announced by Allis-Chalmers. Completely front accessible, the new starter is compact and versatile with the basic unit measuring only 34 in. wide by 32 in. deep. *Allis-Chalmers Manufacturing Company.*

Circle number (89) on reply card.

Analyzer Cuts Engine Costs. A complete, cost-cutting look at the inner mechanical functioning of complex industrial engines, without expensive shutdowns, has been made possible by a new industrial engine analyzer. The hand-portable, multi-purpose equipment displays pictorially the information formerly obtained from as many as 3 electronic instruments. It enables operators and maintenance men to monitor reciprocating engines, whether spark-ignited or diesel, to keep them operating at continuous peak efficiency. It also detects and pinpoints malfunctions as they develop within engines. The lightweight analyzer accurately monitors engine operation, providing 3-types of data: ignition, vibration and pressure. *Sperry Gyroscope Company.*

Circle number (90) on reply card.

Newest addition to the line of rotary drilling rigs manufactured by the George E. Failing Company is a horizontal "Weep Hole" drill. This unit which has a capacity for drilling 4¼-in. horizontal holes to a distance of 300 ft was designed to relieve the causes of earth slides along highways, railroad rights of way, etc., due to excessive moisture. Perforated casing is inserted in the horizontal holes which permits continuous drainage of the affected areas.

Circle number (91) on reply card.

New Equipment

Model LD Ditch-Witch Trencher. The Model LD is completely mobile with trenching speeds up to 8 fpm and road speeds up to 5 mph. Standard trench widths are available from 4 to 16 in. at 2 in. intervals. The machine will dig a 4 or 6 in. trench to a depth of 42 in. Approximately 6 in. less depth is obtainable for each additional 2 in. width of trench.

New features of the Model LD Ditch-Witch are: 18 hp Wisconsin air-cooled engine, automotive type steering, automotive transmission with 3 speeds forward and reverse, reversible spoils conveyor, double acting hydraulic pump for raising bucket line, 15 in. drive wheels for increased traction. *The Charles Machine Works, Inc.*

Circle number (92) on reply card.

Recording Flow Colorimeter. The availability of a new ratio recording flow colorimeter for the continuous analysis of any color in the visible spectrum has been announced by Beckman Instruments.

Packaged in both conventional and explosive-proof housings, the ratio-recorder is unique in that it makes possible the accurate measurement of wave lengths of color ranging from 350 to 1000 millimicrons in the presence of turbidity or entrained gas. In addition, it is relatively insensitive to source variations and to the accummulation of foreign matter on the cell windows of the analyzer section—a problem which has plagued conventional colorimeter users for several years. *Beckman Instruments, Inc., Process Instruments Division.*

Circle number (93) on reply card.

Adjustable Angular Torch Head. The angular machine-torch adapter now being marketed by Air Reduction is adjustable through the wide range of 250 deg. Because of the versatility of the unit, it replaces their entire line of fixed angular heads. The cutting angle can be set without tools, and without removing the accessory from the torch. Any required angle can be set between 0 deg and 90 deg either side of vertical, and within an additional 35 deg above horizontal. Both sides of the body bear indexing marks in increments of 5 deg. *Air Reduction Sales Company, Division of Air Reduction Company, Incorporated.*

Circle number (94) on reply card.

Single Shaft 3250-hp Gas Turbine. A new 3250-hp gas turbine used as a mechanical drive for pumps, compressors or generators has been added to the family of available gas turbines rated at 5000, 8000, and 12,000 hp by the Westinghouse Electric Corporation. The simple open-cycle gas turbine operates at 8500 rpm and any output speed can be obtained through the use of gearing.

At full load, the exhaust flow is approximately 191,000 lb per hour at 775 F. This relatively high exhaust temperature can be used to produce low-pressure steam with a waste heat boiler or a heat exchanger located in the exhaust duct. The gas turbine is 21 ft long, 6 ft wide and 4½ ft high and weighs only 14,000 lb. *Westinghouse Electric Corporation.*

Circle number (95) on reply card.

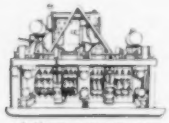
Portable Ultrasonic Testing Instrument. A completely portable, battery-operated ultrasonic thickness measuring unit has been perfected by Magnaflux Corporation. The Sonizon SO-200 locates areas of corrosion or wear. The SO-200 is fast, positive, and simple to operate. It gives direct readings of thickness.

The SO-200 requires no warm-up time. It measures with an accuracy of ± 3 percent on thicknesses between .027 and 4 in., and works on practically all materials which will transmit ultrasonic sound. Specifications are: Unit weight, 8¼ lb; size, 9 x 8 x 9 in.; battery case weight, 11½ lb. *Magnaflux Corporation.*

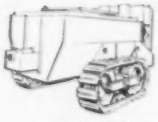
Circle number (96) on reply card.

Sleet and Ice Alarm System. A new method of providing protection against the formation of ice on various outdoor installations has been announced by American Instrument. The Aminco sleet and ice alarm system solves such diversified problems as poor radio and television transmission due to tower icing, the freezing of gas-line pumping stations and trailer-truck loading accidents due to ice or slush-covered loading ramps. This system detects climatic conditions, favoring formation of ice, and automatically actuates defrosting heaters or provides a visual alarm for the manual actuation of the heaters. *American Instrument Co., Inc.*

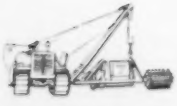
Circle number (97) on reply card.


stationary cleaning & priming machine

pipeline cradles


pipeline kettles

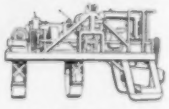
M. J. Crose

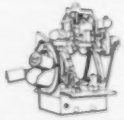

ditch padder

internal line up clamp

pipeline equipment first choice of contractors everywhere

pipe cutting & beveling machine


road boring machine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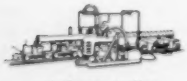
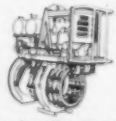
Pipeline construction work — on every continent around the world — goes faster and more economically for hundreds of contractors who depend upon the complete line of Crose equipment. Ruggedly built for top performance anywhere, Crose equipment is available through many strategic supply points.


stationary coating & wrapping machine

Cinch hydraulic pipe bending machine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New Process Moisture Monitor. An instrument for the continuous accurate measurement, remote recording, and control of low moisture levels is now available from Consolidated Electrodynamics. Called the Type 26-310 process moisture monitor, the instrument is built to give trouble-free service under the rugged environmental conditions of process plant locations. It is suited for monitoring moisture content of instrument airstreams and natural gas transmission lines. It may be used for recording moisture levels of feed streams in low-temperature distillation units and in polymerization units. The analyzer unit is about 10x10x13 in., weighs 40 lb, and is weather and explosion-proofed for outdoor installations. The control unit is 2½x13¼x47⅛ in., weighs 5 lb, and is designed for flush-mounting in a control room. The instrument operates on 105 to 125 v, 50/60-cycle ac. *Consolidated Electrodynamics Corporation.*

Circle number (98) on reply card.

Hydraulic Cylinder Attachment. This cylinder replaces the bulldozer blade's left tilt brace and provides in-the-seat blade tilting. Cylinder has a 7¼-in. bore and 7-in. stroke, and is operated by a front-mounted single valve No. 44 hydraulic control. In order to allow maximum blade tilting, bulldozer trunnions have been redesigned on all new No. 7S bulldozers. By use of the hydraulic cylinders, the blade may be tilted to either side, so that the raised corner is approximately 38-in. above the ground. The standard D7 track shoe, of 20-in. width, may be used with the tilt cylinder and redesigned trunnion. *Caterpillar Tractor Co.*

Circle number (99) on reply card.

Davis Backhoe. A popular feature of the Davis Backhoe is the visibility that it affords the operator. The seat travels with the boom. When digging or loading trucks the operator is facing his work.

The Davis Backhoe is available in 2 models: the 210, with the rotary boom swing cylinder that provides 200 deg of continuous operating arc and which can be side mounted for flush digging alongside a wall, fence or other obstruction; and the 185, with its conventional swing cylinder. The 10,000 lb of breakaway power provided by the Davis Backhoe and its exclusive vertical type stabilizers has also proved to be a popular feature. *Massey-Harris-Ferguson Industrial Division.*

Circle number (100) on reply card.

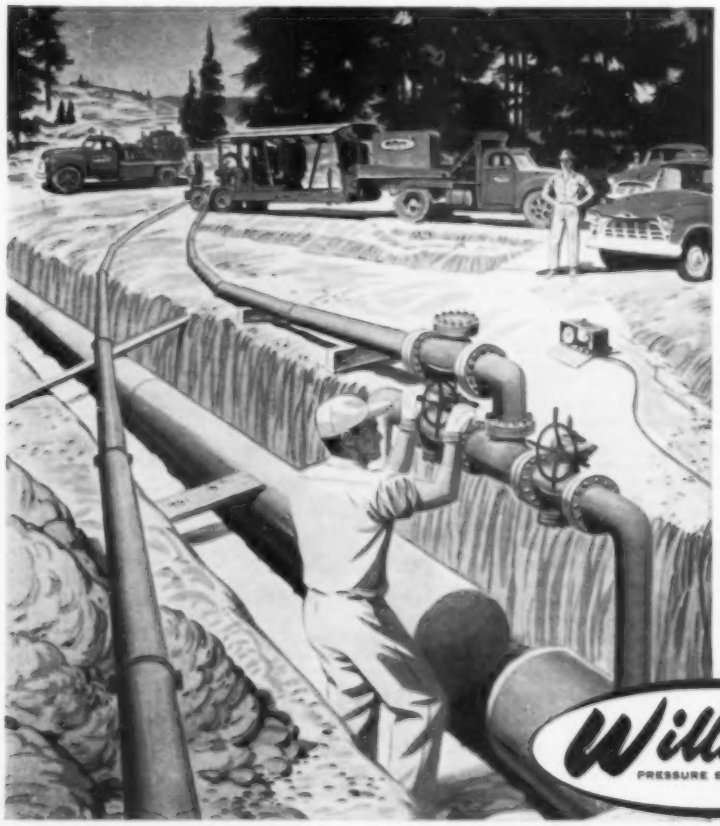
Vertical Weather-Protected Motor. Vertical weather-protected motors with enclosures built to NEMA Type II standard are now available from Allis-Chalmers in squirrel-cage and wound-rotor induction and synchronous types in ratings of 250 hp and up. Designed for outdoor applications on pumps and other vertical drives, the new motors' ventilating passages are constructed to minimize the entrance of rain, snow and airborne particles with baffles to direct the flow of air in and out. Intake and exhaust openings to air chambers are arranged so high velocity air blown into the machine will circulate through and be discharged without entering the internal vent passages leading to electric parts.

Baffles force incoming air to abruptly change its direction — 90 deg or more —before reaching the motor's electric parts. To further assure that moisture or dirt particles will drop out before reaching internal parts, air velocity into the machine is less than 600 rpm. *Allis-Chalmers Manufacturing Company.*

Circle number (101) on reply card.

Omnidirectional Antenna. Andrew Corporation, manufacturer of antenna systems, has produced a new fiberglas radome high gain antenna for the 450-470 mc. The type 212 antenna has a measured gain of 10 db across the entire band and can be used at any frequency in the band without troublesome tuning adjustments. The antenna is supplied in 3 sections, the longest of which is 12 ft. Overall length is 23 ft, with the lower 3 ft for mounting. *Andrew Corporation.*

Circle number (102) on reply card.



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NEW Literature

Pipeline Control System. Askania has issued a folder on automatic pipeline pumping station control. This folder covers 3 basic control systems with diagrams schematically showing the operation of these basic systems. *Askania Regulator Company.*

Circle number (103) on reply card.

Pulse Code. Bulletin CP-3012 explains the Varec pulse code telemetering system equipment in detail. This bulletin offers an alphabetical index as well as a numerical index by figure numbers. The system consists essentially of a gaging device, a transmitter, transmitter selection equipment, a communication link and an indicator-receiver. *The Vapor Recovery Systems Company.*

Circle number (104) on reply card.

Lubricated Plug Valve Bulletin. A new 12-page illustrated lubricating manual for Walworth lubricated plug valves has been issued by the Walworth Company. The manual describes the function of lubricants in lubricated plug valves and the essential properties of an effective lubricant. Detailed information on how to select the right lubricant and how to apply it is presented in text and pictures. *Walworth Company.*

Circle number (105) on reply card.

Packaged Control System. A new bulletin on a packaged remote control system for the control or positioning of valves and other final control elements has been published by A. W. Cash Company, co-developer of the system with Sparton Corporation. Known as the Cash Standard-Sparton Series 300 system, it can simultaneously regulate such process variables as pipeline pressures, flow rate, surge, liquid levels, proportioning and speed at distances up to many miles, from 1 central location with 1 operator.

The system consists of 2 elements: the controller, utilizing a standard power supply, positioner, reducing valves and booster valve in a single compact package; and a supervisory control unit remotely located and transmitting signals to the controller via telegraph, telephone or private wires, or microwave. *A. W. Cash Company.*

Circle number (106) on reply card.

Airco Electrode Guide. Among the many helpful features of this booklet is an electrode consumption calculator, in tabular form, which provides data for calculating consumption per linear foot in the welding of various types of joints. *Air Reduction Sales Company, Division of Air Reduction Company, Incorporated.*

Circle number (107) on reply card.

New Powdered Acid. The properties and uses of Oakite Drycid, the recently introduced powdered acid scale and rust remover, are described in a service report published by Oakite Products. The service report points out the convenience inherent in shipping, storing, and using a powdered rather than liquid acid; the lack of bothersome acid fumes; and the material's increased safety on various metals. One of the major advantages discussed is Drycid's greater safety when used to descale systems containing dissimilar metals. *Oakite Products, Inc.*

Circle number (108) on reply card.

New Rotary Air Compressor. An 8-page, 2-color bulletin, P-106B, describing the Le Roi 600 rotary air compressor, has been issued by Le Roi Division. Thirty-eight photographs are used to illustrate this compressor. Close-up views of 33 features are shown, as well as several overall views of the new compressor. General specifications are listed. *Le Roi Division, Westinghouse Air Brake Company.*

Circle number (109) on reply card.

Power-Safe Electric Brakes. Warner Electric Brake & Clutch Company, announces a complete, fully-illustrated story of Warner's newest electric brake designed for fail-safe applications. This authoritative 36-page illustrated report, WEB 6293, for design engineers includes photographs, drawings, diagrams, and complete explanation of operation, selection factors, torque characteristics and controls. *Warner Electric Brake & Clutch Company.*

Circle number (110) on reply card.

Cushioned Valves. "Golden-Anderson Cushioned Valves in Action" is a new 4-page bulletin published by Golden-Anderson Valve Specialty Company. Schematically shown are various piping and valve arrangements for particular applications. *Golden-Anderson Valve Specialty Company.*

Circle number (111) on reply card.

Differential Converter Specific Gravity Transmitter. The new Honeywell differential converter transmitter, with range continuously adjustable from 0-5 to 0-25 in. of water, is adaptable to the continuous measurement and control of the specific gravity of liquids in open vessels. Several methods of measurement have been found satisfactory. In each, the pressure exerted by a column of reference liquid is balanced against that of an equal column of the measured liquid, and the differential pressure transmitted to a recording instrument actuated by a pneumatic receiver element, as discussed in Instrumentation Data Sheet 10.14-8. *Minneapolis-Honeywell Regulator Company.*

Circle number (112) on reply card.

Pipe Coating Plant. An 8-page, 4-color brochure available from Southern Pipe Coating Company describes the firm's facilities for cleaning, coating and wrapping pipe in all sizes from ¾ through 12-in. in its new Atlanta, Georgia, plant. Drawings illustrate various stages in the wrapping process, and a description is given of the Holiday detection test and other controls which assure that pipe is evenly coated and completely protected. *Southern Pipe Coating Company.*

Circle number (113) on reply card.

Temperature Measuring Instruments. New folder gives details on 2 basic types of fast-reading metal-probe thermometers and shows the various configurations in which they are available. The 2 types listed in the literature are the integral-probe type with the electrical indicating instrument mounted directly on the rigid probe and the remote-probe type, in which the indicating instrument is in a anodized aluminum case and the probe is located at the end of a flexible cable. *Royco Instruments.*

Circle number (114) on reply card.

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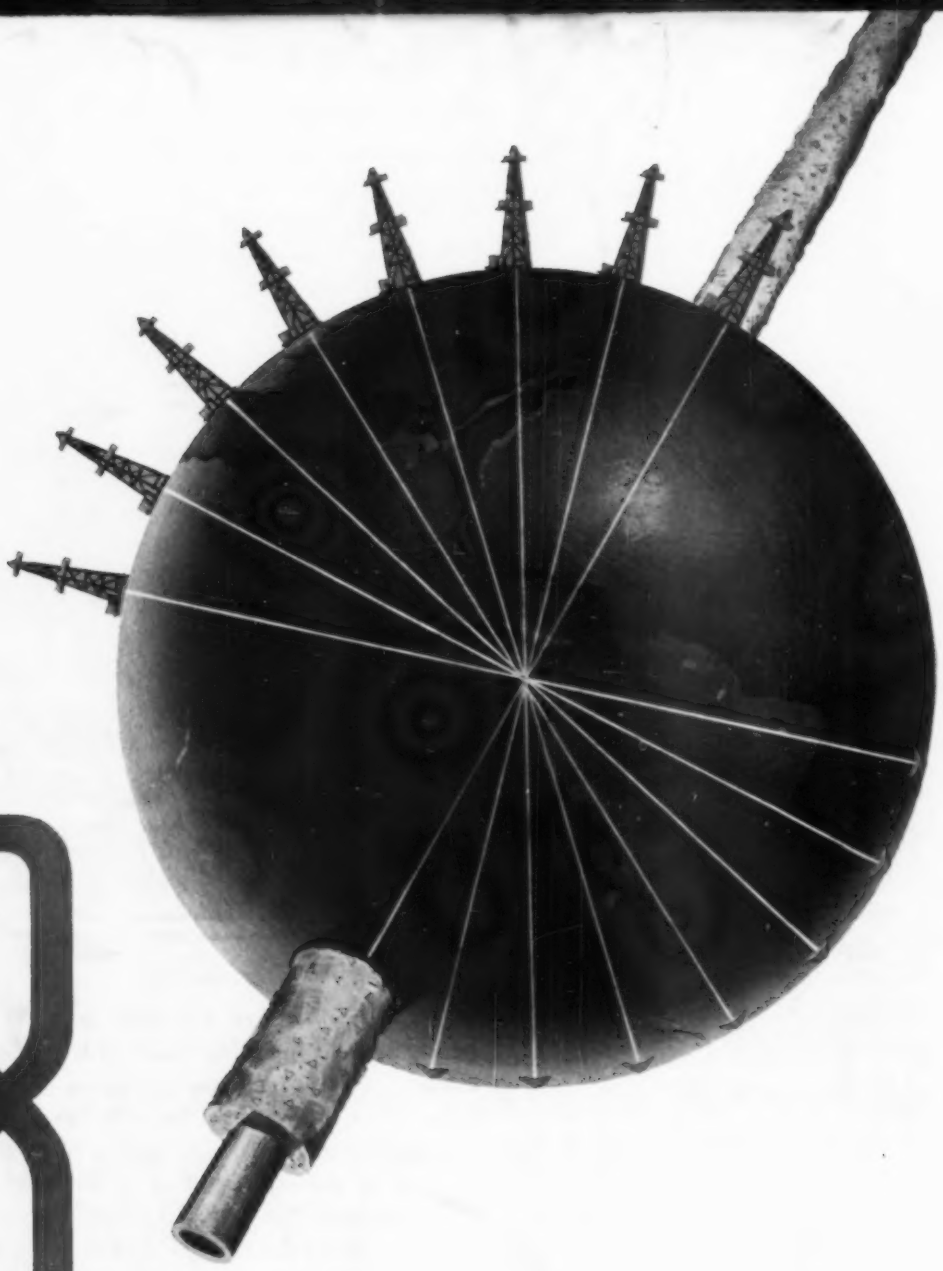

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